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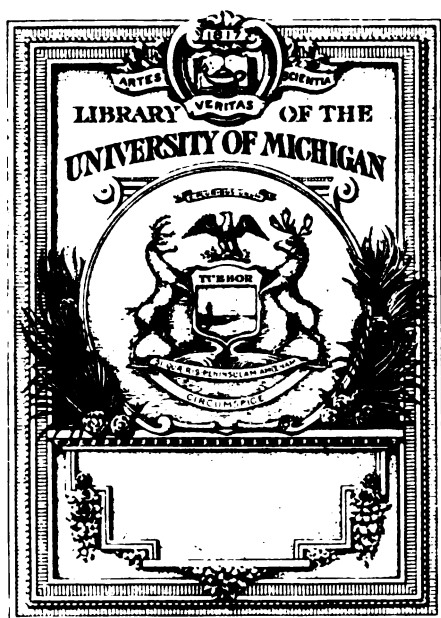
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SEVENTEENTH ANNUAL REPORT

OF THE

NEW JERSEY STATE

Agricultural Experiment Station

AND THE

NINTH ANNUAL REPORT

OF THE

New Jersey Agricultural College Experiment Station

FOR THE YEAR ENDING

October 31st, 1896.



TRENTON, N. J. :

THE J. L. MURPHY PUBLISHING CO., PRINTERS.

1897.

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To His Excellency John W. Griggs, LL.D., Governor of the State of New Jersey :

SIR—I have the honor to submit herewith the seventeenth annual report of the New Jersey State Agricultural Experiment Station, as required by the law establishing the Station, which was approved March 10th, 1880, and which is chapter CVI. of the laws of that year.

ABRAHAM W. DURYEE,

President.

NEW BRUNSWICK, N. J., November 30th, 1896.

To His Excellency John W. Griggs, LL.D., Governor of the State of New Jersey :

SIR—In compliance with an act of Congress, approved March 2d, 1887, and with an act of the Legislature of this State, approved March 5th, 1888, I beg leave to submit, on behalf of the Trustees of Rutgers College in New Jersey maintaining Rutgers Scientific School, the New Jersey State College for the benefit of Agriculture and Mechanic Arts, the ninth annual report of the operations of that department of the College which has been organized in accordance with said act of Congress, and is known as "The State Agricultural College Experiment Station."

AUSTIN SCOTT,

President.

NEW BRUNSWICK, N. J., November 30th, 1896.

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NEW JERSEY AGRICULTURAL EXPERIMENT STATIONS.

1. STATE STATION. ESTABLISHED 1880.

BOARD OF MANAGERS.

HIS EXCELLENCY JOHN W. GRIGGS, LL.D., Trenton, Governor of the State of New Jersey.
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RICHARD TITUS, . . . Janitor and Laboratory Attendant.
VINCENT CARBERRY, . . . Laboratory Assistant.

2. AGRICULTURAL COLLEGE STATION. ESTABLISHED 1888.

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ALFRED A. CANNON, . . . Assistant Clerk.
AUGUSTA E. MESKE, . . . Stenographer and Typewriter.

TREASURER'S REPORT.

Irving S. Upson, in account with the New Jersey Agricultural Experiment Station, October 31st, 1895, to October 31st, 1896:

RECEIPTS.

From State Treasurer..... \$14,998 72

PAYMENTS.

Salaries and pay of chemists and assistants.....	\$8,493 70
Expenses of the Board of Managers.....	35 96
Stationery, including envelopes for Bulletins and Reports.....	354 32
Printing	917 53
Postage.....	310 68
Furniture.....	99 67
Fuel.....	356 15
Gas and water.....	144 20
Laboratory expenses.	922 03
Field and feeding experiments.....	750 30
Freight, express and cartage bills.....	154 22
Expenses collecting samples of fertilizers.....	469 55
Traveling expenses.....	94 51
General fittings, repairs and improvements.....	971 32
Insurance	42 25
Buildings	548 00
Reference-books	51 12
Construction of greenhouse.....	283 21
	\$14,998 72

Respectfully submitted,

IRVING S. UPSON,

Treasurer.

The Auditing Committee of the Experiment Station have examined the accounts of the Treasurer of said Station and find them correct.

SAMUEL R. DEMAREST, JR.,

JESSE B. ROGERS,

Auditing Committee.

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FINANCIAL STATEMENT.

THE TRUSTEES OF RUTGERS COLLEGE

FOR

THE NEW JERSEY STATE AGRICULTURAL COLLEGE EXPERIMENT STATION

IN ACCOUNT WITH

THE UNITED STATES APPROPRIATION, 1895-6.

Dr.

To receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30th, 1896, as per act of Congress approved March 2d, 1887..... \$15,000 00

By Salaries.....	\$9,872 06	
Labor	776 08	
Publications	957 53	
Postage and stationery.....	387 62	
Freight and express.....	88 80	
Heat, light and water.....	196 04	
Chemical supplies.....	128 72	
Seeds, plants and sundry supplies.....	177 93	
Fertilizers	133 63	
Feeding stuffs.....	69 66	
Library.....	625 37	
Tools, implements and machinery.....	55 85	
Furniture and fixtures	74 09	
Scientific apparatus.....	491 23	
Live stock.....		
Traveling expenses.....	465 79	
Contingent expenses.....	59 00	
Building and repairs.....	645 60	
Totals	\$15,000 00	\$15,000 00

We, the undersigned duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the New Jersey State Agricultural College Experiment Station for the fiscal year ending June 30th, 1896; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been \$15,000.00, and the corresponding disbursements \$15,000.00, for all of which proper vouchers are on file, and have been by us examined and found correct, thus leaving no unexpended balance.

And we further certify that the expenditures have been solely for the purpose set forth in the act of Congress approved March 2d, 1887.

Signed,

AUSTIN SCOTT,
EDWARD B. VOORHEES,
G. C. LUDLOW,

Auditors.

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REPORT OF 'THE DIRECTOR.

REPORT OF THE DIRECTOR.

The annual report for 1896 contains a record of the work finished during the year ending with October 31st in the departments of chemistry, biology, botany, horticulture and entomology, as well as statistical matter concerning commercial fertilizers and concentrated feeds for 1895, which could not be obtained until January 1st, 1896, and was therefore omitted from the report of 1895. In all of the departments the work has been prosecuted with energy, and those of botany, horticulture and chemistry, including dairy work, have been materially enlarged because of increased facilities acquired during the year. The chief addition is the College Farm, consisting of 97 acres, which, with its entire equipment, was placed, in April last, at the disposal of the Experiment Station by the Trustees of Rutgers College, "for the purpose of more perfectly and permanently promoting scientific investigation and experiment." This addition is of great value, particularly in two directions—first, in providing land near at hand for studying more fully the lines of work already in progress, because making it possible for the various officers to exercise direct supervision of the experiments, which was heretofore impossible; and, second, in permitting a broader field of investigation in the line of farm economics, of the dairy interests and of horticulture, studies of primary importance in our State.

The organization of the Stations includes the following distinct departments :

- I. Chemistry.
- II. Horticulture.
- III. Dairy Husbandry.
- IV. Biology.
- V. Botany.
- VI. Entomology.

The department of horticulture, as distinct from botany, and that of dairy husbandry, are comparatively new. The former was established in 1895, and the latter was organized this year.

I. CHEMISTRY.

The work of the chemists may be grouped under three heads—first, the analyses of commercial fertilizers and fertilizing materials; second, the analyses of fodders, feeds and farm crops; and, third, analyses of milk.

1. Commercial Fertilizers.

In the exercise of an analysis control, 331 brands of complete fertilizers have been examined this year, as against 271 in 1895, or an increase of 22 per cent. The work, however, has been accomplished by the same force, and has required but little longer time than heretofore, because of the improvement in chemical methods and processes, and an increase in the clerical force.

The increase in the number of brands of complete fertilizers this year is due mainly to an increase in the number of firms selling in the State. This year brands of 89 firms are reported, an increase of 16 over 1895; 11 have dropped and 27 are new this year, and the new firms are represented by 59 brands. Statistics concerning the amount of fertilizers consumed during the past year are not yet available, hence it is impossible to determine whether the consumption is increased in proportion to the increased number of firms doing business in the State. The increase in the number of brands may not indicate a larger consumption by the farmers, because many established firms are induced to increase the number of their brands, and many begin business in a small way or enter the State because of the absence of an analysis tax on the brands, or a direct tax, which is the case in almost every other State where fertilizers are used.

The analyses do not reveal any flagrant attempt at fraud, though the crude preparation of many brands and the wide variations that exist in the cost per pound of the constituents in the different products, and even in different brands from the same manufacturer, indicate that a considerable proportion of those engaged in the business are not possessed of the ordinary facilities required to secure mechanical condition or uniformity, or they do not have a very definite idea of the importance of these points.

A point strongly emphasized by the work of the Station in this direction is, that in the matter of the purchase of fertilizers, intelligence on the part of the consumer is quite as important as the law

providing how products shall be sold ; the guarantee which the law requires may be easily kept, yet the charge for the actual constituents may be so great as to amount virtually to a fraud upon the ignorant consumer. The consumer should, of course, understand the relation that should exist between guarantee and selling price ; and the kind of information which is given by the analyses, which enables him to do this, is quite as important as that showing the relative amount and proportion of the constituents contained in a brand.

Doubtless much would be gained in uniformity of price of constituents to consumers were the law to require that goods should be sold on the "unit" basis rather than on the "ton" basis with a guaranteed analysis. If this were adopted it would increase the cost of the chemical control, but it would result in greater benefit, because every analysis would then have both a direct and an indirect value for all consumers, whereas, under present circumstances, the analysis possesses only an indirect value for the consumer, who does not thoroughly understand the meaning of an analysis and the relation of guarantee to selling prices.

2. Fertilizing Materials.

In addition to the complete fertilizers, 155 samples of fertilizing materials, home and special mixtures, ground bone and miscellaneous products, were analyzed. Of these, 93 were examined chiefly for the purpose of studying the relative cost per pound of the constituents in raw materials, and the relation of the cost per pound of the actual ingredients when contained in mixed and in unmixed fertilizer products.

This line of work has been a matter of special investigation in the past, and the results secured this year confirm the conclusion heretofore reached, viz., that a knowledge of *what* and *how* to buy fertilizers is of the greatest importance, and that the use of this knowledge will result in very great savings in the purchase of supplies. It may be that an average charge by the manufacturers of 38.9 per cent. for mixing, bagging, shipping and selling is not too great to enable them to secure a living profit ; the question for the farmer to determine is whether he can afford to pay these charges when, by an intelligent study of the question as presented by the Station, he may learn how to reduce them.

That the work of the institution in this direction is appreciated and taken advantage of, not only by our own farmers, but by those in surrounding States, is made abundantly evident by the inquiries received for our bulletins and for detailed advice, both as to methods of purchase and use of these materials.

A study of the progress of the fertilizer trade and of the variations that occur in the cost of supplies to the manufacturers, or mixers, from year to year, is made possible by means of carefully-collated statistics, which are published annually; in fact, it is the aim of the Station to provide all the available data necessary for a full understanding of the subject by the consumer.

Much valuable work has also been done by the chemists in the study of analytical methods in co-operation with the Association of Official Agricultural Chemists. The purpose of this Association is to secure greater uniformity in the methods used in the different laboratories and to examine and report upon new methods or forms of apparatus, the object of which is to secure greater accuracy and rapidity in the work. The Association has been so successful in accomplishing its purposes, that the work of the chemists in connection therewith is quite as important as any now engaged in by them. The results are reported to the Association and published in their annual proceedings, and are not included in this report.

3. Fodders and Feeds.

The analyses of fodders and feeds made since the last report have been confined largely to the examination of samples taken in connection with experiment crops, either as a part of a study of their adaptability and usefulness for our conditions, or such as have been made necessary by the investigations in the dairy. Twice in the history of the Stations, systematic sampling and analyses of the commercial feeds of the State have been made, and valuable information gained concerning the variations liable to occur in the composition of the ordinary farm feeds, as well as the actual composition and relative value of the newer and untried concentrated products; the determination of the essential fertilizer constituents contained in the ash also accompanies the food analysis, which is of great importance in showing their relative manurial value. The analyses made thus, besides tables showing the average composition of fodders and feeds, are contained in the body of the report.

The very great usefulness of a knowledge of both the food and fertilizer values of feeds, has never been more apparent than at the present time, when the selling prices of a number of the concentrated feeds, as wheat bran, linseed meal, cotton-seed meal, dried brewers' grains, etc., are so low in price as to make them much cheaper for the Eastern farmer than his home-grown crops; besides, the cost price of many of them is really less per ton than would be the cost price of the fertilizer constituents contained in them if purchased in the form of mixed fertilizers.

4. Analyses of Milk.

One hundred and twenty samples of milk were subjected to a complete analysis, a large number of which were made in connection with a study of the cost and composition of milk as delivered to consumers in the large cities of the State. This study showed very clearly that the standard now in use as the basis of sale, namely, the quart, is illogical and is unfair both to the consumer and to the producer of good milk. In fact, because of the wide variations that occur, the consumer is really affected more in this way than by the actual adulteration that is practiced, because less than 4 per cent. of the whole number examined were directly adulterated. A further study of the relative proportions of the various constituents of these samples indicated that the fat content would serve as a safe guide as to the nutritive value of milk. The fat content only was determined in a number of samples examined in connection with a study of the composition of milk as delivered to creameries, and of the variations in the milk of different cows under uniform conditions of food and management. This work also showed that a wide variation occurred, and that here, too, the fat content should be the only basis of purchase, because the only one fair to both producer and consumer.

II. HORTICULTURE.

The horticultural work of the year has consisted mainly in setting and caring for an experimental orchard of five acres, and in preparing for experimental work in the greenhouse during the winter. The primary object of these experiments in the orchard is to study the need of fruits and berries in respect to plant-food, the influence of different kinds and forms of fertilizing materials upon the yield and

quality of the product, and advantages or disadvantages of different methods of cultivation and management. In order to make this practicable, the leading standard varieties of a number of fruits and berries were chosen—chiefly those which a careful study of the industry of the State showed were well adapted for our soil and market conditions. It was, however, possible to include a few of the newer varieties in order to study their adaptability and probable usefulness.

In addition to this work, a number of vegetables, including asparagus, tomatoes, peas, beans, etc., are being studied to determine their needs in reference to added plant-food and their relative merits as to earliness and quality. In the greenhouse, work is in progress to study the question of soils, fertilizers, methods of growing, and sub-irrigation for the leading glass-house crops, lettuce, tomatoes and melons.

Bulletins are also in course of preparation containing the results of the statistical fruit survey made in 1894-95, arranged in such a manner as to give a practical idea of the methods of fruit culture now practiced in the State, as well as useful information concerning fruit or berry culture for those already engaged in the business, and for those who contemplate entering upon this line of work.

The statistics gathered showed that fruit or berry-growing as a business was, on the whole, more profitable than old-line farming, and that it was very profitable in particular cases where it had been made a subject of careful study, that is, where the information gathered from the Station and elsewhere concerning varieties, methods of manuring, spraying and marketing, etc., was taken advantage of. The adoption of uniform and systematic methods of culture on the part of those who are now careless and unsystematic in their work should greatly improve the business and make it a leading industry in the State.

III. DAIRY HUSBANDRY.

The College Farm is well suited for forage crops, which, in connection with its location, makes it well adapted for the study of the economics of the dairy; it is, therefore, used with its equipment consisting of well-appointed buildings, and possessed of a good dairy herd, to make a study of the crops and rotations best suited for the dairy, their cost of production, relative usefulness, and methods of preservation. During the year, oats and peas, cow peas, soja beans

and barley and peas have been grown as soiling crops; large areas were also sown with crimson clover, which will be used both for green manuring and for soiling.

For the purpose of more fully studying an important question of the day, an experimental silo has been erected, which possesses the advantages now claimed for this system of preservation, and experiments are in progress to determine the comparative cost and usefulness of food as contained in silage and in dry corn fodder. A test of the usefulness of a number of concentrated feeds, both in reference to their influence in milk production and in increasing the fertility value of manures, has been planned, which it is proposed to continue for a series of years. The business side of dairying is also made a subject of study, both in reference to the influence of quality as represented by cleanliness and richness upon the salability of milk and cream, and the cost of production and delivery.

IRRIGATION.

In view of the great losses which our farmers suffer because of lack of water during the critical period in the growth of many important crops, the question of irrigation for our State was made the subject of study. This work was carried out by the Director with the co-operation of the U. S. Department of Agriculture, and the investigation included a careful study of the need of irrigation, the area in southern Jersey that is capable of being watered by gravity, the accessible water-supply for the purpose, the estimated cost of irrigation in these sections, and the use now made of irrigation in connection with the methods used and the results secured.

The meteorological records of the State give abundant proof of the very frequent shortage of water during the growing-season, due both to a deficiency in rainfall and to its unequal distribution, and also that the most serious shortage occurs in sections peculiarly adapted for the growth of vegetables and small fruits. The data in reference to rainfall in connection with those derived from measurements of the flow of streams, show that the State possesses a large supply of water which may in many sections be made accessible at a reasonable expense, and that this valuable resource of the State may be utilized with profit is illustrated by the statistics obtained concerning the cost of irrigation plants already in operation in the State, and the actual

benefits derived from an abundant water-supply. The experimental irrigation plant at the College Farm has been considerably extended, and plans have been perfected for the further study of this question, as applied to all of the small fruits and to many of the vegetables.

IV. BIOLOGY.

The work of this department has been confined chiefly to investigations concerning the tuberculin test for tuberculosis in cattle, and the germ content of milk as found in the udder. The experiments and the results obtained may be outlined as follows:

One line of study has been a continuation of the temperature observations on cattle begun two years ago with the object of discovering the laws governing the normal temperature variations in cows and has been completed. The data secured are valuable in that they enable a more accurate calculation of the extent to which the injection of tuberculin affects the individual cases.

Experiments with tuberculin, injected repeatedly into cattle that have shown themselves tuberculous at previous injections, and also the repetition of such injections upon a cow which has never reacted under such tuberculin test, have also been continued.

The object of these experiments is to find an answer to the questions, "Are healthy cattle injuriously affected by being subjected to the tuberculin test?" and "Are cattle that have a slight degree of tuberculosis benefited, or are they injured by being repeatedly subjected to the influence of tuberculin?"

As regards the first question, no injurious effects of tuberculin injected into healthy cows have been observed; as regards the second question, the data published in last year's report supported the claim that repetition of tuberculin injection tends to cure tuberculosis. This is shown by the fact, first, that the reaction made by tuberculous animals after being injected with tuberculin, grows rapidly less with each subsequent application of the test; and second, that post-mortem examination shows that the tubercles which have been present in such cases have become encysted within dense capsules of connective tissue, thus presumably imprisoning the bacillus which is the cause of tuberculosis and, by starving it, causing disintegration. The work of several other observers has supported the same claims.

Our more recent data show that after tuberculous cattle have lost

the power to react, they regain this power after a period of several months, if they are left untreated in the meantime; and also that tuberculosis may develop its normal course in cattle that have been receiving this course of treatment, the injection of tuberculin appearing to have no conspicuous effect either beneficial or injurious.

Tuberculin, aside from its well-nigh infallible, and therefore precious, power of disclosing the existence of tuberculosis in cattle (under conditions in which the disease is not otherwise discoverable), apparently produces effects of very doubtful value and limited extent, when used for curative purposes.

Studies of the germ content of milk as found in the udder have been begun and promise valuable results. It has been found that the milk just drawn (known as "fore-milk") is very rich in germ content; in some cases a single drop contains many thousands of microbes. Happily the majority of the species present are practically harmless, but because of the widespread notion that the microbic content of milk is derived entirely from outside sources after the milk is drawn, these results are of great importance. A bulletin dealing with the care of tuberculous cattle has also been prepared.

V. BOTANY.

The work in the botanical department has been mainly with field experiments at the College Farm and elsewhere in the State, supplemented with investigations in the laboratory.

The area at the farm has been extended so that now nearly two acres are included in the experiment plots. The chief lines of work have been with fungicides upon turnips, potatoes, sweet potatoes, beans, tomatoes, egg-plants, cucumbers, celery, peppers, beets, peas, and a few sorts of ornamental plants, and the results are of such a character as to enable the Station to recommend methods of practice that will materially aid if not altogether prevent or check diseases that have in the past caused serious losses of these crops.

For example, lime has again proven to be almost a specific for the club-root of turnips, cabbages and allied plants, and this season's work upon the old ground indicates that lime holds fully its fungicidal power up to the third year. The trial upon new ground shows that two years is much too short a time in which to eradicate the club-root from infested land, by the ordinary process of starvation through

a rotation of crops. It has also been shown that the manure from an animal, while being fed with clubbed turnips, becomes a vehicle for the introduction of the disease into the land. Clean soil that received the pulp and water of boiled clubbed turnips did not produce diseased roots, while the same quality of soil which received the uncooked turnips, gave turnips all of which were clubbed. Nearly all of a large number of the members of the turnip series produced roots that were clubbed, and therefore any mustard-like weed may be treated as a possible enemy to the turnip crop.

The experiments for the scab of white potatoes have again shown the great value of sulphur as a remedy, and also that good results have been obtained with kainit.

The experiments with sweet potatoes upon four different fields in the portions of the State where the crop is an important one, confirm the results of last year, that sulphur will reduce the amount of the soil rot and in badly-infested land the use of it can be advocated. Kainit was also beneficial as a check upon the disease, and hence a mixture of 300 pounds of sulphur and an equal amount of kainit per acre can be confidently recommended as a fertilizer-fungicide, for both the scab of the round potato and the soil rot of the sweet potato.

The experiments with beans and tomatoes show that the diseases of these plants, although encouraged by continuous cropping, may be kept down by spraying with fungicides; those with egg-plants and cucumbers were, however, less satisfactory.

The season having been a fairly moist one, the experiments in irrigation have not shown the good effects that were obtained last year, when a drought prevailed. It has been shown, however, that when an excess of water is employed the various fungous enemies abound; thus there was a larger amount of scab upon the irrigated belts of potatoes, and of bacterial blight and anthracnose upon the watered beans. The same is true of the tomatoes and egg-plants.

A study of different fungicides has been made with all of the crops before mentioned, and also upon beets and several ornamental plants. Bordeaux was taken as a standard with which three other compounds have been compared, the lime in each case being replaced with soda, potash or ammonia, and the mixtures called soda-bordeaux, potash-bordeaux and ammonia-bordeaux, the last being the old Eau Celeste with a difference in the formula to make it comparable with bordeaux.

While it is too soon to make a final comparison, the results of the

present year indicate strongly that all three are excellent fungicides. The ammonia-bordeaux requires the greatest caution in its mixing and use, and when properly prepared is very efficient. An objection to the soda-bordeaux is the dark color it assumes when the alkali is in excess. Best of all, as regards the care required in mixing the ingredients, stability of color, adhesiveness of the compound and cheapness, is the potash-bordeaux. It is classed among the clear fungicides, and is thoroughly efficient when placed alongside of and compared with bordeaux, as it was in all the crops. In this replacement of the lime with potash, there is no danger of clogging, the foliage or fruit is not disfigured, besides the potash in the material is worth nearly its first cost as a fertilizer.

In addition to these specific lines, a study of the peach gall, recently a very serious trouble, has been carried out in the Station greenhouse, and an experiment has been planned and is in progress in the house of a prominent rose-grower to study the soil and food requirements of this crop, which is a large industry in the State, and much difficulty has recently been experienced by the growers in meeting the requirements of the market.

The herbarium of the Station has been enlarged by a few hundred specimens, and the index of the host plants now includes more than 20,000 specimens.

Some work has also been done with weeds, and a new device constructed to assist in the detection of foul stuff in commercial seeds.

Since the last report Bulletin No. 115, "Irrigation of Garden Crops," has been published, and a circular concerning asparagus rust was prepared and sent to prominent growers, and to the press of this and adjoining States. Bulletins containing the more important results obtained this year are in course of preparation.

VI. ENTOMOLOGY.

The work of the entomological department has consisted mainly in a study of the San José Scale and its natural enemies. The introduction of this pest into New Jersey so seriously threatened our fruit interests that a special provision was made for this investigation by the Legislature of 1896. The Entomologist visited California and made as full an investigation of the situation there as his time would permit, particularly concerning the agents that were reported to be

responsible for the eradication of the scale in that State, chiefly parasites and predaceous insects that had been introduced from Australia. He also made arrangements to have colonies of these sent into New Jersey, and distributed under his supervision in a number of the worst-infected orchards of the State. Because of the necessity of prompt action, a preliminary report of his observations and studies, and suggestions as to remedial measures, was published in September, as Bulletin No. 116, and a more complete record of his studies is contained in the report of his department, though his final report along this line cannot be concluded until another season has afforded opportunity to study the effect produced by the colonies set free in the orchards here.

The report is interesting in showing that this scale in California is controlled not by the Australian lady-bird, as reported, but by well-directed efforts on the part of the fruit-growers, assisted by natural causes and by climatic conditions unfavorable for their spread; that dependence cannot be placed upon natural enemies for the control of the scale here, and that the means likely to prove successful is a continuous warfare with the remedies given in Bulletin No. 116.

The other lines of work in this department included a study of the army worm, which invaded certain sections of the State the past year; of the harlequin cabbage bug, an insect new in our State; and a further study of methods for reducing the ravages of the melon louse, which was particularly destructive the past season. A bulletin is now in course of preparation on this subject. The report also contains a record of further observations concerning the Hessian fly, cut worm, pear midge and other insects, which have been described in the past, and for which effective remedies have been recommended. It is very gratifying to note that the recommendations of the Entomologist are carefully observed by a constantly-increasing number of our farmers with the most satisfactory results.

FARMERS' MEETINGS.

The policy of the Stations in the past is still adhered to in reference to the attendance of the officers at farmers' meetings, though the increased number now held throughout the State requires much more time than formerly, both in the preparation of matter and in travel. The advantages of such work, both in increasing the efficiency of the institution by enabling the officers to more fully understand the needs

of the farmers and in carrying directly to them the results of our work is, however, believed to more than compensate for the time required.

CORRESPONDENCE.

The usefulness of the Station is not limited to its work of a scientific and practical character; it serves in addition as a bureau of information not only in matters pertaining to farming, but in many cases in matters only indirectly connected therewith but of interest to the general public. This work is constantly increasing, and the time required in handling the correspondence is very great. In the departments of entomology, botany and chemistry, it requires on the average about two hours per day of the time of the chief officer in each department throughout the year to answer the letters of inquiry received. I mention the farmers' meetings and correspondence especially because I believe these lines to be a very valuable part of the work of the Station, and because discussions concerning them do not appear elsewhere in the report as a part of the work of the departments.

EQUIPMENT.

Aside from the addition of the farm and its equipment, the various departments are well supplied with needful scientific appliances and apparatus. In the departments of chemistry and horticulture much has been added the past year. In order to do advanced work many pieces of new apparatus are annually required, and it is the aim of the officers to keep well abreast of the times in this respect. The library is also well supplied with the important technical works and the standard periodicals and journals connected with the science of agriculture, and many additions are annually made. Much progress has also been made during the year in securing complete files of Station literature.

REPORT OF THE CHEMISTS.

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REPORT OF THE CHEMISTS.

FERTILIZERS.

I.

FERTILIZER STATISTICS.

- 1. The quantity and value of the fertilizers used in New Jersey during the year 1895.*
- 2. Comparison of this year's trade with that of preceding years.*
- 3. The market prices of fertilizers.*

These statistics were taken by manufacturers from their books in answer to requests made by this Station. The reports were in each case returned on printed forms, of which the following is a copy :

SALES OF COMMERCIAL FERTILIZERS.

The following is a correct statement of the number of tons of the several classes of Commercial Fertilizers sold in New Jersey by ——— during the year ending November 1st, 1895.

Number of tons of	Complete Manure.....	
"	"	Ammoniated Superphosphate without Potash, including
		Dissolved Bone, etc.....
"	"	Ground Bone.....
"	"	Kainit.....
"	"	Muriate of Potash.....
"	"	Nitrogenous matter.....
		(a) Ammonium Sulphate.....
		(b) Sodium Nitrate.....
		(c) Blood, Ammonite, etc.....
Number of tons of	Plain Superphosphates, including both Dissolved Bone	
	Black and S. C. Acid Phosphate.....	

The above circular was mailed to 87 firms, 74 of which, including those that have the largest sales in this State, forwarded itemized statements. These indicate a total consumption for 1895 in New Jersey of 51,149 tons, divided as follows :

1.

THE QUANTITY AND VALUE OF THE FERTILIZERS USED IN NEW JERSEY DURING THE YEAR 1895.

	Tons reported as sold in New Jersey.	Average retail price per ton.	Total value.
Complete Manures.....	39,118	\$32.87	\$1,285,809
Dissolved Bone, etc.....	1,743	28.04	48,874
Ground Bone.....	2,489	30. 5	77,085
Kainit.....	1,529	11.94	18,256
Muriate of Potash.....	1,225	40.00	49,000
Ammonite, Dried Blood, Dried Fish, etc.....	*1,441	27.55	39,701
Ammonium Sulphate.....	61	65.50	3,996
Sodium Nitrate.....	236	42.93	10,131
Bone-Black Superphosphate.	930	18.06	16,796
S. C. Rock Superphosphate.....	2,377	11.04	26,242
Total number of tons and value.....	51,149	.....	\$1,575,840

* Includes 300 tons of hair manure, at \$7 per ton.

Although it is admitted that these statistics are incomplete, as they represent only about four-fifths of the manufacturers who sell fertilizers in this State, yet the firms which did reply represent the greater part of the fertilizers sold in the State; those manufacturers who have not replied, as a rule, being those whose total output averages less than 50 tons per annum.

As stated in previous annual reports, this statistical work is carried out without legal authority, the data being secured only through the courtesy of those manufacturers who, year after year, at their own expense, compile their reports in answer to direct requests.

The inspectors who represent this Station report the retail prices of every brand sampled by them. These reports furnish the data from which the above average retail prices for complete manures are obtained. The average retail prices for kainit and all other products tabulated below it were secured from sales made directly by the manufacturers to farmers, consequently they do not include charges for freight, cartage, etc.

The complete manures represent 76 per cent. of the total number of tons sold in 1895, and 82 per cent. of the total value of all sales.

2.

COMPARISON OF THIS YEAR'S TRADE WITH THAT OF PRECEDING YEARS.

The total sales reported in 1895 are somewhat less than those of the two preceding years. The complete fertilizers, 39,118 tons, are practically the same as in 1894, and indicate an expenditure of about \$1,286,000. In raw materials an increase is noticed in all cases except dissolved bone, ground bone, sodium nitrate and bone-black superphosphate. The decrease in dissolved bone and ground bone is very marked.

Tonnage of Fertilizers Used in New Jersey.

	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.
Number of tons of Complete Manure.....	24,498	22,500	25,413	23,864	27,236	29,431	33,821	37,927	39,319	39,118
“ “ Ammoniated Superphosphate without Potash (Dissolved Bone, etc.).....	1,343	1,898	1,016	1,067	998	1,101	1,628	2,222	3,124	1,743
“ “ Ground Bone.....	2,338	2,465	2,036	1,498	1,679	2,735	2,308	3,021	3,291	2,489
“ “ Kainit.....	1,106	1,220	604	625	567	784	825	1,056	1,313	1,529
“ “ Muriate of Potash.....	255	314	449	491	393	560	552	695	906	1,225
“ “ Ammonite.....	*698	.....	*1,703	†306	305	†128	†422	†418	†764	†1,141
“ “ Ammonium Sulphate.....	21	95	53	95	97	92	103	113	86	61
“ “ Sodium Nitrate.....	24	93	157	205	133	151	193	221	285	236
“ “ Blood.....	.....	411	.....	.....	.....	.....	.....	.....	.....	.....
“ “ Fish.....	.....	184	.....	1,184	1,009	1,988	958	902	777	.....
“ “ Hair.....	723	383	.....	677	.....	761	1,353	1,696	460	300
“ “ Poudrette.....	5,000	.....	.....	.....	.....	.....	.....	†301	†20	.....
“ “ Bone-Black Superphosphate.....	594	370	457	572	4,925	2,898	2,048	1,208	1,195	980
“ “ S. C. Rock Superphosphate.....	2,078	1,303	1,745	1,662	2,174	3,845	8,443	1,978	1,929	2,377
Total.....	38,678	31,216	33,633	32,246	39,516	43,414	47,654	51,758	53,469	51,149

* The total number of tons in 1886 and 1888, under Ammonite, includes both blood and fish, returns having been made, in many cases, without discrimination. † The total number of tons, in 1889, 1891, 1892, 1893, 1894 and 1895, under Ammonite, includes blood, ‡ Cotton-seed meal.

The Average Retail Prices for 1886, 1887, 1888, 1889, 1890, 1891, 1892, 1893, 1894 and 1895.

	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.
Complete Manure.....	\$36.68	\$34.80	\$34.83	\$38.07	\$34.64	\$34.23	\$34.19	\$34.11	\$34.17	\$32.87
Ammoniated Superphosphate without Potash (Dissolved Bone, etc.).....	29.25	32.63	31.90	31.83	32.00	29.64	30.86	31.33	28.70	28.04
Ground Bone	34.35	35.39	33.76	34.46	32.74	31.99	31.35	32.50	30.35	30.95
Kainit	10.60	10.25	12.83	12.10	12.28	13.44	13.49	11.43	11.92	11.94
Muriate of Potash.....	42.00	39.54	42.83	39.75	41.75	42.05	42.47	41.22	41.38	40.00
Ammonite.....	*40.40	.....	*36.66	*34.60	31.84	33.00	40.00	45.60	41.58	40.00
Ammonium Sulphate.....	70.00	68.20	69.70	71.18	68.63	69.20	66.97	67.28	72.82	65.50
Sodium Nitrate.....	58.72	51.61	52.00	51.62	44.83	46.39	44.77	49.27	45.18	42.93
Blood.....	.....	35.33	.....	.....	.....	33.00	32.67	45.60	41.58	36.50
Fish.....	.....	35.17	.....	.....	.....	31.08	34.05	34.00	35.00	35.00
Hair.....	10.00	.....	.....	.....	.....	7.00	.....	7.00	7.00	7.00
Poudrette.....	10.00	.....	.....	.....	.....	.....	.....	.....	.....	.....
Superphosphates made from Bone Black.....	25.85	26.95	24.80	24.55	22.00	21.08	20.89	18.98	20.51	18.06
“ “ S. C. Rock.....	17.75	17.73	15.60	15.80	14.00	15.39	14.50	14.44	12.04	11.04

*The prices for blood, ammonite and fish have been averaged for the years 1886, 1888 and 1889, for reasons mentioned above.

The question has been raised whether the variations in the average price of complete manures have been accompanied by corresponding variations in the absolute amounts of plant-food actually delivered to consumers. To answer this the analyses made by the Station in the past year have been averaged, with the following results :

	Total. Nitrogen. Per cent.	Total. Phos. Acid. Per cent.	Available. Phos. Acid. Per cent.	Insoluble. Phos. Acid. Per cent.	Potash. Per cent.
1895 average of 271 samples	2.80	10.74	7.84	2.90	4.80
1894 " " 223 "	2.87	10.40	7.37	3.03	4.94
1893 " " 243 "	2.69	10.23	7.54	2.69	4.58
1892 " " 196 "	2.74	10.38	7.70	2.67	4.50
1891 " " 212 "	2.71	10.12	7.29	2.83	4.21
1890 " " 198 "	2.65	10.62	7.70	2.92	4.41
1889 " " 178 "	2.90	10.82	7.88	2.94	4.20
1888 " " 153 "	2.77	10.91	8.09	2.82	4.29
1887 " " 153 "	2.79	10.87	7.69	3.18	4.22
1886 " " 146 "	2.66	10.82	8.07	2.75	3.87
1885 " " 103 "	2.61	11.10	8.33	2.83	3.79

An examination of these figures indicates that no decided change in the average quality of fertilizers has occurred during the past eleven years. This is rendered more definite by computing cash valuations on the basis of the Station's schedule for 1895.

On this basis a fertilizer, to represent the average for each of the eleven years, would be valued as follows :

1895.....	\$24.15 per ton.
1894.....	23.77 "
1893.....	23.13 "
1892.....	23.40 "
1891.....	22.61 "
1890.....	23.13 "
1889.....	23.99 "
1888.....	23.84 "
1887.....	23.51 "
1886.....	22.94 "
1885.....	23.15 "

The decline in prices of complete fertilizers from 1885 to 1895, therefore, was not accompanied by a corresponding decrease in the absolute amounts of plant-food delivered to consumers.

The total cash value of the reported sales of commercial fertilizers in this State during 1895, as compared with that of previous years, is as follows :

Total value of fertilizers reported for 1882.....	\$1,070,113.00
" " " " " " 1884.....	1,369,004.00
" " " " " " 1885.....	1,116,670.00
" " " " " " 1886.....	1,181,266.00
" " " " " " 1887.....	1,022,434.00
" " " " " " 1888.....	1,125,881.00
" " " " " " 1889.....	1,106,223.00
" " " " " " 1890.....	1,247,004.00
" " " " " " 1891.....	1,346,482.00
" " " " " " 1892.....	1,509,921.00
" " " " " " 1893.....	1,641,615.00
" " " " " " 1894.....	1,715,767.00
" " " " " " 1895.....	1,575,840.00

THE MARKET PRICES OF FERTILIZERS.

The preceding records show that the farmers of this State paid nearly \$1,286,000 last season for complete manures. It is therefore a matter of importance to ascertain the principal conditions which influence the selling price of these materials.

Complete fertilizers are made by mixing a number of crude products, each of which contains one or more of the following elements of plant-food, viz., nitrogen, phosphoric acid and potash. Efforts have been made, therefore, to secure :

The average wholesale prices of nitrogen, phosphoric acid and potash.

The average retail prices of nitrogen, phosphoric acid and potash.

The advances in prices between the wholesale and retail markets.

The wholesale prices are quoted every Monday in the well-known trade journal, *The Oil, Paint and Drug Reporter*. These prices have been tabulated for the entire year, and have then been recalculated in order to express the results in the form adopted by the experiment stations of this country.

The retail prices were calculated from the analyses of those samples of raw materials published in the report of 1895, which were taken from goods in the hands of farmers and which had been bought for cash direct from the manufacturers of complete fertilizers.

A comparison of the retail and wholesale prices, secured as above described, gives the following :

	AVERAGE PERCENTAGES BY WHICH THE RETAIL PRICES EXCEED THE WHOLESALE.		
	1893.	1894.	1895.
Nitrogen from Nitrate of Soda.....	26.0	8.3	21.8
“ “ Sulphate of Ammonia.....	8.2	9.9	.....
“ “ Dried Blood.....	12.4	22.8	31.4
“ “ Ammonite .....	.....	.....	26.3
Soluble Phosphoric Acid from S. C. Rock.....	48.6	56.7	35.3
Reverted “ “ “ “ “	48.6	56.7	35.3
Potash from High-Grade Sulphate of Potash.....	21.4	8.9	7.1
“ “ Double Sulphate of Potash and Magnesia..	23.9	.....	.....
“ “ Kainit	25.0	26.3	30.6
“ “ Muriate of Potash.....	10.8	7.9	8.3

A summary of these averages for seven years shows a difference of 26.5 per cent. between the wholesale and retail prices of nitrogen. This is much wider than ever before and is largely due to the unusually low wholesale prices which ruled for all ammoniates during 1895. In the case of available phosphoric acid the difference has been diminished about 21 per cent., while in potash there is a slight increase of 1 per cent.

SUMMARY.

Retail Prices Exceed Wholesale by the Following Percentages.

	1889	1890.	1891.	1892.	1893.	1894.	1895.
Nitrogen.....	12.5	15.4	10.8	21.6	15.5	13.7	26.5
Phosphoric Acid...	48.8	43.6	73.0	72.2	48.6	56.7	35.3
Potash.....	16.0	16.5	22.4	26.6	20.3	14.4	15.3

THE WHOLESALE PRICES OF NITROGEN, PHOSPHORIC ACID
AND POTASH IN CRUDE PRODUCTS.

The following table shows the wholesale prices of actual plant-food during the year 1895. They are derived from the wholesale prices of crude products, as taken from the *Oil, Paint and Drug Reporter*, and have been calculated upon the basis of the following analyses :

Nitrate of Soda.....	16	per cent. Nitrogen.
Sulphate of Ammonia.....	20½	" "
Dried Blood and Ammonite.....	12½	" "
Acid Phosphate.....	12	" { Available Phos- phoric Acid.
High-Grade Sulphate of Potash.....	50	" Potash.
Double Sulphate of Potash and Magnesia,	25	" "
Muriate of Potash.....	50	" "
Kainit.....	12½	" "
Sylvinit	15	" "

Wholesale Prices in New York, per Pound, of Plant-Food.

MONTHS.	WHOLESALE COST PER POUND OF NITROGEN IN FORM OF—								WHOLESALE COST PER POUND OF POTASH IN FORM OF—												
	NITRATE OF SODA.		SULPHATE OF AMMONIA.		AZOTINE.		DRIED BLOOD.		ACID PHOS- PHATE.		MURIATE OF POTASH.		KAINIT.		STYLINIT.		DOUBLE SUL- PHATE OF POTASH AND MAGNESIA.		HIGH-GRADE SULPHATE OF POTASH.		
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Max.	Min.	Max.	Min.	Max.	Max.	Min.	Max.	Max.	Min.
January.....	12.3	12.0	15.3	14.8	13.0	12.7	12.8	11.9	3.8	3.2	3.7	3.5	3.8	3.4	4.4	4.6	4.4	4.3	4.1		
February.....	11.6	11.1	15.3	15.3	.....	.....	11.2	10.9	3.8	3.0	3.7	3.5	3.8	3.4	4.6	4.6	4.4	4.3	4.1		
March.....	10.5	10.3	15.1	14.8	.....	.....	10.6	10.3	3.8	3.0	3.7	3.5	3.9	3.4	4.5	4.7	4.5	4.3	4.2		
April.....	10.4	10.1	14.5	14.1	.....	.....	10.7	10.6	3.8	3.0	3.7	3.6	3.9	3.4	4.6	4.7	4.5	4.3	4.2		
May.....	10.4	10.2	14.0	13.4	.....	.....	11.0	10.7	3.8	3.0	3.7	3.6	3.8	3.4	4.6	4.7	4.5	4.3	4.2		
June.....	11.0	10.7	13.8	13.6	12.4	12.1	11.1	10.8	3.8	3.0	3.7	3.6	3.8	3.4	3.9	3.4	4.7	4.5	4.3	4.2	
July.....	1.0	10.6	13.5	13.2	12.4	12.1	10.7	10.4	3.8	3.0	3.7	3.6	3.8	3.4	3.8	3.4	4.7	4.5	4.3	4.2	
August.....	10.9	10.6	12.9	12.6	12.4	12.1	10.1	9.9	3.8	3.0	3.7	3.6	3.8	3.4	3.8	3.4	4.7	4.5	4.3	4.2	
September.....	11.3	11.1	12.7	12.4	12.4	12.1	10.2	9.9	3.6	2.9	3.7	3.6	3.8	3.4	3.8	3.4	4.7	4.5	4.3	4.2	
October.....	11.5	11.3	12.4	12.0	11.6	11.4	10.2	9.7	3.8	2.5	3.7	3.6	3.9	3.4	3.8	3.4	4.7	4.5	4.3	4.2	
November.....	11.6	11.4	12.3	12.0	10.9	10.6	10.1	9.9	2.8	2.5	3.7	3.6	3.9	3.4	3.8	3.4	4.7	4.5	4.3	4.2	
December.....	11.1	10.9	12.2	11.7	10.6	10.3	9.3	9.6	2.8	2.5	3.7	3.6	3.9	3.4	3.8	3.4	4.7	4.5	4.3	4.2	
Average for 1895.....	11.0		13.5		11.8		10.5		3.3		3.6		3.6		3.8		4.6		4.3		
Average for 1894.....	13.3		17.1		14.4		13.6		3.0		3.3		3.3		3.8		4.8		4.5		
Average for 1893.....	13.3		15.3		15.9		15.3		3.1		3.7		3.6		3.8		4.6		4.3		

The prices of all nitrogenous fertilizing materials show a very decided decrease, varying from 2.2 cents in nitrate of soda to 3.6 cents in sulphate of ammonia less per pound than in 1894. Marked fluctuations are noticed during the year, especially in sulphate of ammonia, which has decreased from 15.3 cents in January to 11.7 cents in December. The price of acid phosphate has varied from 3.8 to 2.5 cents, while the prices of the potash salts, excepting sylvinite, have remained practically constant throughout the year.

**AVERAGE RETAIL PRICES OF NITROGEN, PHOSPHORIC ACID AND
POTASH IN CRUDE PRODUCTS.**

With few exceptions, the samples of raw materials analysed in 1895 were taken from goods in the hands of farmers, and had been bought for cash direct from the manufacturers of complete fertilizers. After an analysis of the samples, therefore, it was not difficult to calculate the retail prices per pound of the various forms of nitrogen, phosphoric acid and potash used in this trade.

The tables on pages 22 to 26 in the report of 1895, furnish in detail the information gained by this work, and afford data also for the following summary. For comparison, results secured in a similar manner in 1888, 1889, 1890, 1891, 1892, 1893 and 1894 are republished:

COST PER POUND OF—		1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.
		cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.
Nitrogen from Nitrate of Soda.....		16.8	16.0	14.2	14.7	14.1	15.5	14.3	13.4
“ “ Sulphate of Ammonia.....		17.0	17.2	16.9	16.9	16.5	17.1	18.8	.....
“ “ Dried Blood.....		14.4	20.0	16.0	16.0	15.1	17.2	16.7	13.8
“ “ Dried Fish.....		15.8	14.9	14.1	14.1	15.2	16.8	17.5	16.4
“ “ Ammonite.....		15.4	.....	.....	.....	15.2	.....	.....	14.9
Soluble Phosphoric Acid from Bone Black...		7.5	7.4	6.7	6.6	6.5	6.2	6.5	5.8
“ “ “ “ S. C. Rock....		6.2	6.1	5.6	6.4	6.2	5.5	4.7	4.3
Reverted “ “ “ “ Bone Black...		7.5	7.4	6.7	6.6	6.5	6.2	6.5	5.8
“ “ “ “ S. C. Rock....		6.2	6.1	5.6	6.4	6.2	5.5	4.7	4.3
Insoluble “ “ “ “ Bone Black...		1.9	1.8	1.7	.....	.....	.....	.....	.....
“ “ “ “ S. C. Rock....		1.5	1.5	1.4	.....	.....	.....	.....	.....
Potash from High-Grade Sulphate.....		4.7	5.6	5.5	4.7	5.3	5.1	4.9	4.5
“ “ Double Sulphate Potash and Magnesia.....		6.1	6.0	.....	5.8	5.5	5.7	.....	.....
“ “ Kainit.....		5.1	4.8	5.0	5.3	5.5	4.5	4.8	4.7
“ “ Muriate.....		4.0	3.9	4.2	4.1	4.2	4.1	4.1	3.9
“ “ Sylvinit.....		.....	.....	5.4	.....	.....	.....	.....	.....

These averages are the manufacturers' retail cash prices for the nitrogen, phosphoric acid and potash in the crude stock from which complete fertilizers are made.

COMPARISON BETWEEN THE AVERAGE WHOLESALE AND RETAIL PRICES OF NITROGEN, PHOSPHORIC ACID AND POTASH.

The conclusions reached in regard to the wholesale and retail prices are here tabulated. They represent the manufacturers' *wholesale* and *retail* prices for plant-food in its *best forms*. The percentages by which the retail prices exceed the wholesale have been taken as the basis of the comparison.

	MANUFACTURERS' AVERAGES.				AVERAGE PERCENTAGE BY WHICH THE RETAIL PRICES EXCEED THE WHOLESALE.		
	Wholesale prices for 1894.	Retail prices for 1894.	Wholesale prices for 1895.	Retail prices for 1895.	1898.	1894.	1895.
Nitrogen from Nitrate of Soda	cts. 18.2	cts. 14.8	cts. 11.0	cts. 13.4	26.0	8.8	21.8
“ “ Sulphate of Ammonia	17.1	18.8	13.5	.....	8.2	9.9	.....
“ “ Dried Blood.....	13.6	16.7	10.5	13.8	12.4	22.8	31.4
“ “ Dried Fish.....	.....	17.5	.....	16.4	.....	.....	.....
“ “ Ammonite.....	14.4	.....	11.8	14.9	.....	.....	26.8
Soluble Phosphoric Acid from Bone Black.....	.....	6.5	.....	5.8	.....	.....	.....
“ “ “ “ S. C. Rock.....	8.0	4.7	8.2	4.8	48.6	56.7	35.8
Reverted “ “ “ Bone Black.....	.....	6.5	.....	5.8	.....	.....	.....
“ “ “ “ S. C. Rock.....	8.0	4.7	8.2	4.8	48.6	56.7	35.8
Potash from High-Grade Sulphate	4.5	4.9	4.2	4.5	21.4	8.9	7.1
“ “ Double Sulphate of Potash and Magnesia	4.8	.....	4.6	.....	28.9	.....	.....
“ “ Kainit.....	8.8	4.8	8.6	4.7	25.0	26.8	30.6
“ “ Muriate.....	8.8	4.1	8.6	8.9	10.8	7.9	8.8

II.

THE CHEMICAL EXAMINATION OF FERTILIZERS.

1. *Introduction.*
2. *The trade values of fertilizing ingredients for 1896, and the examination of the standard materials supplying them.*
3. *The examination of home mixtures and special compounds.*
4. *The examination and valuation of manufactured brands, and sundry materials.*

1.

INTRODUCTION.

The Fertilizer Law.

The fertilizer law of this State is as follows :

An act to regulate the manufacture and sale of fertilizers [approved March 24th, 1874, and amended March 27th, 1878].

1. That every commercial fertilizer which shall be offered for sale in this State shall be accompanied by an analysis, stating the percentage therein of ammonia, or its equivalent of nitrogen ; of potash, in any form or combination, soluble in distilled water ; and of phosphoric acid in any form or combination ; the portion of phosphoric acid soluble in distilled water ; that portion soluble in a neutral solution of citrate of ammonia at a temperature not exceeding one hundred degrees Fahrenheit ; and that portion of phosphoric acid not soluble in either of the above-named fluids, shall each be determined separately ; and the material from which the phosphoric acid is obtained shall also be stated ; a legible statement of such analysis shall accompany all packages or lots of over one hundred pounds sold, offered or exposed for sale.

5. That any person selling, offering or exposing for sale any commercial fertilizer without the analysis required by the first section of this act, or with an analysis stating that said fertilizer contains a larger percentage of any one or more of the constituents mentioned in said section than is contained therein, shall forfeit fifty dollars for the first offense and one hundred dollars for each subsequent offense ;

provided, further, that the provisions of this section shall not apply to any manure sold at a price not exceeding one-half a cent per pound, nor to any imported guanos.

From the Station's standpoint this involves :

1. *The securing of samples.*
2. *The selection of the sample for examination.*
3. *The chemical analysis.*

1. The Securing of Samples.

In order that the inspection of fertilizers may be of value to the State, it is necessary that the samples analysed should be beyond question as to having been properly taken and carefully preserved, so as to fairly and justly represent the bulk of the material from which they are drawn. Success in this particular depends as much on experience, is often as difficult to attain and is quite as important as the subsequent chemical work in the laboratory. For this reason the samples analysed under the act are with few exceptions taken by duly-authorized Inspectors, many of whom have been doing this work for the Station for years. These gentlemen are farmers of the highest standing in the community, and are willing to assume this duty solely because it is regarded as a matter of vital interest to the farming public.

The names of those who have represented the Station during the past season are as follows :

INSPECTORS FOR 1896.

CHARLES KRAUS.....	Egg Harbor City.....	Atlantic county.
H. I. BUDD.....	Mount Holly.....	Burlington county.
L. W. NICHOLSON.....	Camden.....	Camden county.
J. H. RICHARDSON.....	Rio Grande.....	Cape May county.
T. F. D. BAKER.....	Bridgeton.....	Cumberland county.
WM. R. WARD.....	Lyons Farms.....	Essex county.
J. C. GRISCOM.....	Woodbury.....	Gloucester county.
AUGUSTUS DILTS.....	Copper Hill.....	Hunterdon county.
J. M. DALEYMPLE.....	Hopewell.....	Mercer county.
J. M. WHITE.....	New Brunswick.....	Middlesex county.
J. H. DENIER.....	Freehold.....	Monmouth county.
J. J. MITCHELL.....	Troy Hills.....	Morris county.
GEO. A. MACBEAN.....	Lakewood.....	Ocean county.
WOODRUFF PETTIT.....	Salem.....	Salem county.
D. N. WARBASSE.....	Huntsburg.....	Sussex county.
DENNIS C. CRANE.....	Westfield.....	Union county.
B. F. WARD.....	Hainesburg.....	Warren county.

At the beginning of the season each Inspector is furnished with a sampling tube, blanks for describing samples, bottle labels, etc., together with printed instructions regarding their use. Each Inspector is requested to secure a sample of every brand of commercial fertilizer that he can find in his district. A copy of the instructions, under which all samples are taken, is as follows:

DIRECTIONS TO BE FOLLOWED IN SAMPLING FERTILIZERS.

Inspectors may sample fertilizers found either:

First—Upon farms.

Second—In dealers' storehouses; or

Third—In manufactories.

The Station prefers that samples should be drawn either upon farms or in dealers' storehouses.

In sampling fertilizers found upon farms, Inspectors should ascertain:

First—That they are not part of stock of a past season, or of stock which is or has been carelessly stored.

Second—That they were received in good condition; and have since been so stored that a noticeable gain or loss of moisture has been prevented.

In sampling from *dealers' storehouses*, Inspectors should also ascertain whether the fertilizers are of old (last season's goods) or of new stock. Preference should always be given to the present season's goods. Circumstances may, however, make it advisable to sample old stock; in such cases, this fact must be distinctly stated by the Inspector in his report to the Station's Director.

If for any reason it is found to be necessary to draw samples at factories, Inspectors should decline:

First—To sample from piles of fertilizers.

Second—To sample from bags which are not distinctly marked with the brand, the manufacturer's name, and the guaranteed analysis.

If fertilizers are found stored in piles only, Inspectors should cause six or more bags to be filled from different portions of the piles; from these bags the samples may be drawn in the usual manner.

Whenever the mechanical condition will allow, samples should be drawn by means of the *sampling tube* furnished by the Station.

It is not desirable to sample lots of less than one-half ton of any one brand. In such small lots portions may be taken from each bag; in large lots each fifth or tenth bag may be opened. The several portions representing the same product should then be carefully mixed and a quart fruit jar filled, securely closed, and marked with labels furnished by the Station.

As soon as a sample has been taken, and *invariably* before bags of another brand have been opened, the Inspector should carefully fill out the blank describing samples. He should copy *from the bags*:

First—The brand.

Second—The name of the manufacturer.

Third—The guaranteed analysis.

The other information needed for the description must be secured from the owner of the fertilizer.

Each sample bottle should be separately wrapped in heavy paper, and carefully packed for transportation in a wooden box, properly closed. This box should be forwarded by express, directed to

THE NEW JERSEY AGRICULTURAL EXPERIMENT STATION,
New Brunswick, N. J.

Form for Description of Sample.

In taking fair average samples, such as will justly represent the manufacturer as well as the consumer, it is very important that every precaution be taken, so that in case of a suit at law, the person signing the description can testify to its accuracy. The writing should be plain and legible. The filled-out form, if wrapped with the sample, will serve as a label. If any printed circular, analysis or statement accompanies the fertilizer, or is used in its sale, send a copy with the specimen.

1. Brand of fertilizer.
 2. Name and address of manufacturer
 3. Name and address of dealer from whose stock this sample is taken.....
 4. Date of taking the sample.....
 5. Selling price per ton, hundred, bag or barrel.....
 6. Selling weight claimed for each package weighed.....
 7. Actual weight of packages opened..
 8. Total amount of this material on hand.....
 9. Copy of analysis or composition affixed to packages of this fertilizer.....
 10. Signature..
- (To be signed in every case by the person taking sample.)
11. P. O. address.....

2. The Selection of the Sample for Examination.

As fast as the samples are secured they are shipped to the Station. Many duplicates are received but all are given a distinguishing number and properly stored, and an entry is made for each in an appropriate book, showing at a glance the name of the brand and the place or places where it has been found. From among the duplicates of each brand a selection is made at random, but with the aim in view of causing the analyses representing any one firm to be of samples drawn from as many different counties of the State as possible.

This method of selection, it is believed, is more likely to cause the analyses to demonstrate the general quality of a manufacturer's product and to disarm any suspicion or insinuation on the part of rival dealers that the goods were specially prepared to be sampled, which might arise if the sample analysed was taken upon request.

Under certain conditions, however, this rule is not strictly adhered to. When purchases are to be paid for according to the Station's analysis and their magnitude warrants, or when the analysis will add to the information of the Station, or will demonstrate a possible development of waste products into cheap sources of plant-food, or in other ways is of general interest, the Station performs the work free of charge; but in all cases it requires that full and sufficient information concerning the sample be furnished, in order that there may be no unnecessary duplication of work, and, when accomplished, the analysis may be of service to the general public.

The following is a list of those business houses the analyses of whose goods are published in this report.

MANUFACTURERS, ETC.,

WHOSE GOODS HAVE BEEN SAMPLED AND ANALYSED THIS YEAR.

J. H. Allen.....	Lawrence Station, N. J.
J. J. Allen's Sons.....	Philadelphia, Pa.
Armour & Co	Chicago, Ill.
Warren Atkinson.....	Mullica Hill, N. J.
H. J. Baker & Bro.....	No. 93 William St., New York City.
Baugh & Sons Co.....	No. 20 S. Delaware Ave., Philadelphia, Pa.
The Berg Co.....	Port Richmond, Philadelphia, Pa.
Bowker Fertilizer Co.....	No. 27 Beaver St., New York City.
Bradley Fertilizer Co.....	No. 92 State St., Boston, Mass.
E. G. Brick.....	Penn Grove, N. J.
John Brown & Co.....	Philadelphia, Pa.
Brumfield & Foster.....	Colora. Md.
Chandler, Russell & Chandler.....	Newark, N. J.
The Chemical Co. of Canton	No. 32 S. Charles St., Baltimore, Md.
The Clark's Cove Fertilizer Co.....	No. 81 Fulton St., New York City.
E. A. Clendennin & Bro.....	Colora, Md.
E. Frank Coe Co..	No 133 Front St., New York City.
J. S. Collins & Son	Moorestown, N. J.
Cooper Glue Co.....	New York City.
A. S. Core Fertilizer Works.....	Buffalo, N. Y.
G. W. & H. Corson.....	Plymouth Meeting, Pa.
Crocker Fertilizer and Chemical Co.....	No. 56 Pearl St., Buffalo, N. Y.
L. S. Curtis.....	Frenchtown, N. J.

L. B. Darling Fertilizer Co.....	Pawtucket, R. I.
J. J. Dilatash.....	Allentown, N. J.
H. W. Doughten.....	Moorestown, N. J.
J. G. Downward & Co.....	Coatesville, Pa.
Eastern Farm Supply Association.....	Montclair, N. J.
Easton Lime Co.....	Easton, Pa.
Runyon Field.....	Bound Brook, N. J.
J. C. Fifield & Sons.....	Bakersville, N. J.
Lorenz Fisher.....	Belford, N. J.
Garrison & Minch.....	Bridgeton, N. J.
Theodore Glaser.....	Elizabeth, N. J.
W. R. Grace & Co.....	New York City.
Great Eastern Fertilizer Co..	Rutland, Vt.
S. M. Hess & Bro.....	Reading, Pa.
Ira Hill.....	Copper Hill, N. J.
Hires & Co.....	Quinton, N. J.
B. F. Hires.....	Bridgeton, N. J.
W. B. Hitchner.....	Woodstown, N. J.
Hopler & Lomasson.....	Belvidere, N. J.
The Keystone Chemical Manufacturing Co.....	Camden, N. J.
Samuel Lederer & Son.....	New Brunswick, N. J.
Lister's Agricultural Chemical Works.....	Newark, N. J.
Frederick Ludlam.....	No. 108 Water St., New York City.
The Mapes F. & P. Guano Co.....	No. 143 Liberty St., New York City.
Millsom R. & F. Co.....	No. 963 William St., East Buffalo, N. Y.
Minch & Harris.....	Bridgeton, N. J.
Mitchell Manufacturing Co.....	Tremley, N. J.
Mixer & Mickel.....	Bridgeton, N. J.
L. Moritz.....	Philadelphia, Pa.
Munroe, Lalor & Co.....	Oswego, N. Y.
National Fertilizer Co.....	Bridgeport, Conn.
National Plant Food Co.....	Washington, D. C.
Albert Nelson.....	Allentown, N. J.
Newark Agricultural Co.....	Newark, N. J.
New Jersey Farmers' Exchange.....	Elmer, N. J.
New York Fertilizer and Chemical Co.....	New York City.
Niagara Manufacturing Co.....	Buffalo, N. Y.
James E. Otis.....	Tuckerton, N. J.
Pacific Guano Co.....	Cor. Gold and Fulton Sts., New York City.
Packers' Union Fertilizer Co	No. 150 Nassau St., New York City.
S. L. Pancoast.....	Mullica Hill, N. J.
Palapoco Guano Co.....	Baltimore, Md.
Peterson & Smith.....	Woodstown, N. J.
Moro Phillips Chemical Co.....	No. 131 S. Third St., Philadelphia, Pa.
G. H. Poinsett.....	Mullica Hill, N. J.
Preston Fertilizer Co.....	No. 83 Fulton St., New York City.
The Quinnipiac Co.....	No. 83 Fulton St., New York City.
Rancocas Chemical Works.....	Philadelphia, Pa.
Read Fertilizer Co.....	No. 88 Wall St., New York City.

John S. Reese & Co.....	Calvert and Fayette Sts , Baltimore, Md.
Edward Rigg, Jr.....	Burlington, N. J.
L. Sanderson.....	New Haven, Conn.
R. Savidge.....	Mount Rose, N. J.
Scott Fertilizer Co.....	Elkton, Md.
Sharpless & Carpenter	No. 114 S. Delaware Ave., Philadelphia, Pa.
M. L. Shoemaker & Co.....	Delaware Ave. and Venango St., Philadelphia, Pa.
John I. Smith.....	Trenton, N. J.
Rufus W. Smith.....	Elmer, N. J.
Smith & Flowers.....	No. 251 Plane St., Newark, N. J.
Susquehanna Fertilizer Co.....	Baltimore, Md.
Swift & Co.....	Chicago, Ill.
H. S. Taveau & Co.....	Baltimore, Md.
Taylor & Brush.....	New York City.
Taylor Bros.....	Camden, N. J.
The Taylor Provision Co.....	Trenton, N. J.
I. P. Thomas & Sons Co	No. 2 S. Delaware Ave., Philadelphia, Pa.
Thomas Phosphate Syndicate.....	Germany.
Trenton Bone Fertilizer Co.....	Trenton, N. J.
The J. E. Tygert Co.....	No. 42 S. Delaware Ave., Philadelphia, Pa.
The Tygert-Allen Fertilizer Co.....	No. 2 Chestnut St., Philadelphia, Pa.
Walker, Stratman & Co.....	No. 45 Third St., Pittsburg, Pa.
Geo. M. Wells.....	Moorestown, N. J.
J. Wenderoth & Sons.....	Camden, N. J.
West Jersey Marl and Transportation Co.....	Woodbury, N. J.
W. E. Whann.....	William Penn, Pa.
M. E. Wheeler & Co.....	Rutland, Vt.
W. Wilde.....	Vineland, N. J.
Williams & Clark Fertilizer Co.....	No. 81 Fulton St., New York City.
Sam'l Winterbottom & Co.....	Egg Harbor City, N. J.
O. W. Worstall.....	Millville, N. J.
F. B. Young.....	Pennington, N. J.

3. The Chemical Analysis.

The chemical analysis includes a test for the three forms of nitrogen, viz., as nitrates, as ammonia salts and as organic matter, and a quantitative determination of each when found. Likewise the total phosphoric acid is determined, and also that portion of it which is soluble in water, and those soluble and insoluble in ammonium citrate solution.

Potash and chlorine determinations are also made, and the potash found in excess of that needed to form muriate of potash with the chlorine present, is credited to the manufacturer as being in the form of sulphate.

This complete examination is of value in furnishing information.

regarding the kind and quality of the materials used in mixed fertilizers.

The section of the fertilizer law published in the introduction to this chapter, indicates that in this State certain analyses must be made according to prescribed methods; in the others the methods to be used are left to the judgment of the officers of the Station, and are those recommended by the Association of Official Agricultural Chemists.

2.

THE TRADE VALUE OF FERTILIZING INGREDIENTS FOR 1896, AND THE EXAMINATION OF THE STANDARD MATERIALS SUPPLYING THEM.

In most States in which a fertilizer control is exercised it is customary to estimate and affix a commercial valuation to the various materials analysed. This estimated commercial value, it must be clearly understood, is separate and distinct from the agricultural value, the latter depending upon the character and form of the material with reference to its availability and the needs and value of the crop for which it is to be applied. The former, on the other hand, is by market and trade conditions, such as supply and demand, the cost of production, the methods of manipulation required, etc. It is derived by applying to the various forms of plant-food ingredients, as shown by the analysis, the values previously determined upon for them. These values are fixed from year to year, and are altered according to the cost of the standard materials containing these forms of plant-food, as shown in market reports and actual transactions.

The wholesale prices per pound of plant-food prevailing in New York during the six months immediately preceding March 1st last were for nitrogen in nitrate of soda 11.1 cents, in sulphate of ammonia 12.0 cents, in azotine 11.2 cents and in dried blood 9.9 cents; for available phosphoric acid in acid phosphate 2.6 cents, and for actual potash in muriate of potash, kainit or sylvinit 3.6 cents, in double sulphate of potash and magnesia 4.5 cents and in high-grade sulphate of potash 4.2 cents.

From this as a basis the following schedule of trade values was arranged at a meeting of Station Directors and Chemists for use in Connecticut, Massachusetts, Rhode Island, Vermont and New Jersey during the season of 1896:

Schedule of Trade Values Adopted by Experiment Stations for 1896.

				Cents per pound.
Nitrogen in Nitrates.....				13.5
" " Ammonia Salts.....				15.0
Organic Nitrogen in dried and fine-ground fish, meat and blood, and in mixed fertilizers.				14.0
" " " castor pomace and cotton-seed meal.....				12.0
" " " fine-ground bone and tankage.....				13.5
" " " fine-medium bone and tankage.....				12.0
" " " medium bone and tankage.....				9.0
" " " coarser bone and tankage.....				3.0
" " " horn shavings, hair and coarse fish scrap.....				3.0
Phosphoric Acid, soluble in water.....				5.5
" " " " ammonium citrate*.....				5.5
" " " insoluble, in fine bone and tankage..				5.0
" " " " fine-medium bone and tankage				4.0
" " " " medium bone and tankage.....				2.5
" " " " coarser bone and tankage.....				2.0
" " " " mixed fertilizers.....				2.0
" " " " fine-ground fish, cotton-seed meal, castor pomace and wood ashes....				4.5
Potash as Muriate.....				4.5
" " Sulphate and in forms free from Muriates (or chlorides),				5.0

Valuation of Fertilizing Ingredients in Fine-Ground Feeds.

Organic Nitrogen.....	12.0
Phosphoric Acid.....	4.5
Potash	5.0

Average Cost Per Pound of Plant-Food Constituents.

The results of analysis of 88 samples of standard raw materials appear in tabulated form upon subsequent pages. In connection with these is given the cost per pound of the essential fertilizing ingredient which it supplies. This is derived by dividing the cost per ton by the number of pounds of that ingredient in a ton, as determined by analysis. The samples represent the purchases of farmers' clubs and of individuals, by the carload and by the ton, both from the larger dealers

*The solubility of phosphates, in ammonium citrate solutions, is seriously affected by heat. An act of the Legislature (see Laws of New Jersey, 1874, page 90) provides that in this determination the temperature used shall not exceed 100° Fahr.; in Connecticut, Rhode Island and Massachusetts 156° Fahr. has been adopted. The higher the temperature the larger will be the percentage of phosphoric acid dissolved by ammonium citrate solutions, and the larger the amount of so-called "reverted" phosphoric acid in a ton of superphosphate the lower will be the price per pound of said acid. Consequently the Station's valuations of phosphoric acid, soluble in ammonium citrate, have been fixed at *five* cents per pound for Connecticut, Massachusetts and Rhode Island, and at *five and one-half* cents per pound for New Jersey.

in fertilizer supplies and from the smaller dealers resident in the immediate neighborhood of the purchaser. Therefore, if the cost per pound of the nitrogen, phosphoric acid or potash in these samples be averaged, the result may be fairly assumed to represent the average manufacturers' actual retail price at factory for the same, and admit of a comparison with the Station's price, *which is intended to represent the retail cash cost per pound of the fertilising ingredients contained in the raw materials before they have been mixed to form the various commercial brands.*

COMPARISON BETWEEN STATION'S SCHEDULE AND MANUFACTURERS'
AVERAGE RETAIL PRICES OF PLANT-FOOD IN FERTILIZER SUP-
PLIES AS DERIVED FROM ACTUAL TRANSACTIONS.

COST PER POUND OF—	MANUFACTURERS' AVERAGE RETAIL PRICES FOR		STATION'S SCHEDULE OF PRICES FOR
	1895.	1896.	1896.
	cts.	cts.	cts.
Nitrogen from Nitrate of Soda.....	13.4	12.7	13.5
“ “ Sulphate of Ammonia.....		13.8	15.0
“ “ Dried Blood.....	13.8	11.9	14.0
“ “ Dried and Ground Fish.....	16.4	13.7	14.0
“ “ fine-ground bone and tankage.....	12.1	10.8	13.5
“ “ fine-medium bone and tankage.....	10.6	9.6	12.0
“ “ medium bone and tankage.....	8.3	7.2	9.0
“ “ coarse bone and tankage.....	3.9	3.0	3.0
Phosphoric Acid Available from Bone Black.....	5.8	5.6	5.5
“ “ “ “ S. C. Rock.....	4.3	4.5	5.5
“ “ Insoluble, in fine-ground bone and tankage...	4.2	4.0	5.0
“ “ “ “ fine-medium bone and tankage...	3.4	3.2	4.0
“ “ “ “ medium bone and tankage.....	2.3	2.0	2.5
“ “ “ “ coarse bone and tankage.....	1.5	1.0	2.0
Potash from Muriate.....	3.9	4.0	4.5
“ “ Kainit.....	4.7	4.7	4.5
“ “ Sulphate.....	4.5	4.4	5.0

The study of the table shows that the Station's prices are as high as, or higher than, the average of the various manufacturers' prices, except in two cases, viz., kainit, where the average cost per pound of actual potash was raised from 4.4 cents by including two samples which were purchased under less favorable conditions at 5.6 cents and 5.7 cents per pound respectively, and bone-black superphosphate in which a similar condition exists. The application of this schedule to the constituents in mixed goods is, therefore, perfectly fair to the manufacturers in showing the relative commercial value of the different brands.

A further study of the tables which follow will show that, while varying considerably in price, nitrate of soda, sulphate of ammonia and the potash salts are quite uniform in their composition, and comparatively safe to purchase without special chemical examination, although of course they should be accompanied by a guarantee. The samples of dried blood also are quite uniform with the exception of two, which are lower in nitrogen by reason of containing phosphoric acid. The organic materials, such as dried blood, dried and ground fish, tankage, and ground bone are always more or less variable, and are best purchased with special reference to a guarantee. In a majority of these cases this has been done, and the amounts of plant-food guaranteed have been delivered to the consumer. The samples of South Carolina rock superphosphate, or acid phosphate, contain available phosphoric acid in amounts varying but seldom from 12 per cent., although 14 was in many cases guaranteed. Of the eighteen samples, five only show this amount, and among these are some of the lowest in price per ton. To avoid this uncertainty, a system of purchase in which only the amounts actually delivered are paid for, is recommended. In view of the wide variations shown to exist in the cost of the same kind of plant-food it must again be reiterated that *whatever method of purchase is adopted the consumer owes it to himself to carefully study the conditions of the market, to make up his order early, and by combining with others to purchase for cash in considerable quantities, whereby he will get better quotations than those who buy at the busiest season of the year, in small lots at a time, on credit and of the nearest dealer.*

It pays quite as well, proportionately, to use good business methods in the purchase of fertilizer supplies, as in the sale of produce.

Chemical Analyses of Fertilizing Materials.

FORMS OF NITROGEN

Readily and Completely Soluble in Water.

NITRATE OF SODA

Furnishing Nitrogen in Form of Nitrates.

Station Number.	FROM WHOM RECEIVED.	Percentage of Nitrogen.	Cost of Nitrogen per lb.	Cost of 2,000 lbs. of Nitrate of Soda.
6815	J. H. Denise, Freehold.....	16.06	cts.	\$36 00
6820	Runyon Field, Bound Brook.....	16.08	11.2	36 40
6844	H. I. Budd, Mount Holly.....	15.88	11.8	37 40
6876	Chas. Kraus, Egg Harbor City.....	15.70	14.3	45 00
6911	.....	16.00	14.1	45 00
7006	Dennis C. Crane, Westfield.....	16.06	14.0	45 00
7051	Purchased by Station.....	15.81	12.7	40 00
7057	H. I. Budd, Mount Holly.....	15.70	11.9	37 40
7116	L. W. Nicholson, Camden.....	15.57	12.7	39 50
Average Cost per Pound.....			12.7	

SULPHATE OF AMMONIA

Furnishing Nitrogen in Form of Ammonia.

Station Number.	FROM WHOM RECEIVED.	Percentage of Nitrogen.	Cost of Nitrogen per lb.	Cost of 2,000 lbs. of Sulphate of Ammonia.
7081	Runyon Field, Bound Brook.....	20.62	cts. 12.7	\$52 50
7817	I. W. Nicholson, Camden.....	19.61	14.9	58 50
Average Cost per Pound.....			13.8	

FORMS OF NITROGEN INSOLUBLE IN WATER

Furnishing Nitrogen in Form of Organic Matter.

DRIED BLOOD.

Station Number.	FROM WHOM RECEIVED.	Percentage of		Cost of 2,000 lbs. of Dried Blood.	
		Phosphoric Acid.	Nitrogen.	Gen per lb.	
6814	J. H. Denise, Freehold	0.41	13.96	cts.	
6821	Bunyon Field, Bound Brook	0.49	13.66	11.5	\$32 00
6845	H. I. Budd, Mount Holly	0.97	13.77	13.6	36 " 00
6846	" " " "	0.48	13.56	13.5	
6858	H. C. McLean, Red Bank	0.46	11.11	11.6	37 " 00
7052	Purchased by Station	1.27	10.86	9.5	28 " 00
7060	H. I. Budd, Mt. Holly	0.44	13.26	13.8	37 " 00
Average Cost per Pound				†11.9	

* \$1.85 per unit of ammonia.

† In calculating the cost per pound of nitrogen, the value of the phosphoric acid contained in the samples was regarded.

DRIED AND GROUND FISH.

Station Number.	FROM WHOM RECEIVED.	Percentage.		Cost per Pound.		Cost of 2,000 lbs. of Fertiliser.
		Nitrogen.	Phosphoric Acid.	Nitrogen.	Phosphoric Acid.	
6863	C. Kraus, Egg Harbor City	7.96	6.40	cts.	cts.	\$29 00
6892	" " " "	8.41	7.79	13.7	4.5	30 " 00
6912	" " " "	8.30	7.98	16.3	4.5	34 " 00
6917	H. I. Budd, Mount Holly	4.90	5.58	15.3	4.5	20 " 00
6926	" " " "	7.70	6.35	14.5	4.5	28 " 00
6939	" " " "	8.13	8.39	16.8	4.5	35 " 00
7058	" " " "	5.78	6.75	10.4	4.5	18 " 00
7059	" " " "	7.23	6.91	8.0	4.5	18 " 00
7083	J. Taylor, Port Monmouth	11.40	8.19			*24 00
7400	" " " "	8.57	7.13	13.7	4.5	30 " 00
7421	C. C. Hulbert, Matawan	8.01	7.40			*28 50
Average Cost per Pound				13.7		

* For the material unground ; therefore cost per pound not estimated.

FORMS OF NITROGEN INSOLUBLE IN WATER

Furnishing Nitrogen in Form of Organic Matter.

GROUND BONE AND TANKAGE.

Station Number.	FROM WHOM RECEIVED.	Mechanical Analysis.				Percentage.		Cost of 2,000 lbs. of Fertilizer.
		Finer than $\frac{1}{8}$ in.	Finer than $\frac{1}{16}$ in.	Finer than $\frac{1}{32}$ in.	Coarser than $\frac{1}{8}$ in.	Nitrogen.	Phosphoric Acid.	
6779	S. C. De Cou, Moorestown.....	59	22	14	5	6.24	14.78	\$20 00
6780	R. Field, Bound Brook.....	13	66	10	11	3.46	12.15	12 89
6987	H. C. McLean, Red Bank.....	60	21	19	.....	6.69	13.43	20 00
7044	C. Kraus, Egg Harbor City.....	49	20	11	20	7.71	7.14	27 00
7082	R. Field, Bound Brook.....	76	22	2	.....	4.77	17.16	17 50
7420	C. C. Hulsart, Matawan.....	44	40	8	8	2.95	14.35	18 50
7480	D. C. Lewis, Cranbury.....	59	28	16	2	5.40	16.21	25 00
6815	J. H. Denise, Freehold.....	67	24	7	2	1.99	28.13	22 50
6822	R. Field, Bound Brook.....	79	13	8	.....	3.22	25.48	24 00
6847	H. I. Budd, Mount Helly.....	84	12	4	.....	2.97	26.86	21 50
6985	H. C. McLean, Red Bank.....	58	24	21	2	2.57	24.04	24 00
7058	Purchased by Station.....	35	37	28	.....	3.94	23.96	23 00

GROUND BONE AND TANKAGE.

Station Number.		Cost of Nitrogen per lb. in—				Cost of Phosphoric Acid per lb. in—			
		Finer than $\frac{1}{8}$ in.	Finer than $\frac{1}{16}$ in.	Finer than $\frac{1}{32}$ in.	Coarser than $\frac{1}{8}$ in.	Finer than $\frac{1}{8}$ in.	Finer than $\frac{1}{16}$ in.	Finer than $\frac{1}{32}$ in.	Coarser than $\frac{1}{8}$ in.
6779	Tankage	cts. 9.8	cts. 8.7	cts. 6.4	cts. 2.2	cts. 3.6	cts. 2.9	cts. 1.8	cts. 1.4
6780	"	10.4	9.3	6.9	2.8	3.9	3.1	1.9	1.5
6987	"	9.6	8.5	6.4	.....	3.6	2.8	1.8	.....
7044	"	16.6	14.3	11.1	8.7	6.2	4.9	3.1	2.5
7082	"	8.2	7.8	5.5	.....	3.1	2.4	1.5	.....
7420	"	9.7	8.6	6.5	2.2	3.6	2.9	1.8	1.4
7480	"	12.4	11.0	8.8	2.8	4.6	3.7	2.3	1.8
6815	Ground Bone.....	9.9	8.8	6.6	2.2	3.7	2.9	1.8	1.5
6822	"	10.1	9.0	6.7	.....	3.7	3.0	1.9	.....
6847	"	8.8	7.8	5.9	.....	3.8	2.6	1.6	.....
6985	"	12.4	11.0	8.2	2.7	4.6	3.7	2.3	1.8
7058	"	11.1	9.8	7.4	.....	4.1	3.3	2.1	.....
Average Cost per Pound.....		10.8	9.6	7.2	3.0	4.0	3.2	2.0	1.0-

GERMAN POTASH SALTS

Readily Soluble in Distilled Water.

MURIATE OF POTASH.

Station Number.	FROM WHOM RECEIVED.	Percentage of Potash.	Cost of Potash per lb.	Cost of 2,000 lbs. of Muriate.
6798	Theo. Brown, Swedesboro.....	48.12	cts	\$39.00
6818	J. H. Denlee, Freehold.....	52.54	4.5	39.90
6827	Bunyon Field, Bound Brook.....	46.50	3.7	38.50
6861	H. I. Budd, Mount Holly.....	52.89	3.9	38.50
6862	"	52.45	3.5	37.10
6876	Chas. Kraus, Egg Harbor City.....	54.53	4.4	43.00
6883	"	49.58	4.5	45.00
6919	H. I. Budd, Mount Holly.....	45.40	3.9	38.00
6990	Henry C. McLean, Red Bank.....	51.43	3.6	37.25
7009	Dennis C. Crane, Westfield.....	51.52	4.5	45.00
7055	Purchased by Station.....	49.09	4.0	40.00
7228	J. C. Griscom, Woodbury.....	46.30	4.1	38.00
7246	J. M. White, New Brunswick.....	50.14	4.5	42.50
7819	I. W. Nicholson, Camden.....	47.92	4.1	39.50
Average Cost per Pound.....			4.0	

KALINIT.

Station Number.	FROM WHOM RECEIVED.	Percentage of Potash.	Cost of Potash per lb.	Cost of 2,000 lbs. of Kalinit.
6776	John S. Dey, Cranbury.....	12.29	cts	\$14.00
6861	H. I. Budd, Mount Holly.....	12.62	5.7	11.10
7056	Purchased by Station.....	12.39	4.4	10.00
7061	H. I. Budd, Mount Holly.....	12.75	4.0	10.25
7247	J. M. White, New Brunswick.....	12.64	4.9	12.50
7248	"	12.57	5.6	14.00
7330	I. W. Nicholson, Camden.....	12.15	4.7	11.50
7423	J. M. White, New Brunswick.....	12.61	4.6	11.50
Average Cost per Pound.....			4.7	

GERMAN POTASH SALTS

Readily Soluble in Distilled Water.

HIGH-GRADE AND DOUBLE SULPHATES OF POTASH.

Station Number.	FROM WHOM RECEIVED.	Percentage of Potash.	Cost of Potash per lb.	Cost of 2,000 lbs. of Sulphate.
6826	Runyon Field, Bound Brook.....	49.45	cts. 4.4	\$43.75
6850	H. I. Budd, Mount Holly.....	43.57	4.2	41.00
6826	Runyon Field, Bound Brook.....	25.77	4.5	23.40
Average Cost per Pound.....			4.4	

3.

THE EXAMINATION OF HOME MIXTURES AND SPECIAL COMPOUNDS.

Home Mixtures.

Home mixing has been carried on with entire satisfaction by a large number of farmers for several years. The Station has encouraged their efforts as of value to the individuals themselves and an object lesson to their neighbors, since it renders them familiar with the kinds and forms of plant-food, teaches them to think of pounds of nitrogen, phosphoric acid and potash rather than tons of a particular phosphate, and in general unfolds the mystery which envelops the make-up of fertilizers in the minds of many.

In the accompanying table are published the analyses, valuations and cost of home mixtures which were made up this year according to the following formulas, selected by the farmers themselves:

6819. Mixed by John B. Conover, Freehold. Consists of 200 pounds of nitrate of soda, 300 pounds of dried blood, 400 pounds of bone meal, 400 pounds dissolved bone black, 350 pounds of dissolved South Carolina rock and 350 pounds of muriate of potash.

6932. Mixed by W. J. Evans, Marlton. Consists of 200 pounds of nitrate of soda, 250 pounds of dried blood, 500 pounds of dissolved bone, 650 pounds of dissolved South Carolina rock and 400 pounds of muriate of potash.

6991. Mixed by Henry C. McLean, Red Bank. Consists of 100 pounds of nitrate of soda, 100 pounds of dried blood, 100 pounds of tankage, 562 pounds of dissolved South Carolina rock and 200 pounds of muriate of potash.

Home Mixtures and Special Compounds

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	Nitrogen.					Phosphoric Acid.					Potash.		Value of 2,000 lbs. at Station's Prices.	Cost of 2,000 lbs.	Station Number.			
	From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available.							
											Found.	Guaranteed.						
6819 Monmouth Grange Mixture.....	1.21	.....	2.88	4.09	3.69	4.20	5.80	2.50	12.09	.....	9.59	9.00	9.63	8.00	9.29	\$24.58	6819	
6882 Evans' Home Mixture.....	1.59	.....	1.86	3.45	†	5.40	1.54	2.58	9.52	†	6.94	†	10.39	†	10.30	27.51	26.85	6882
6891 McLean's Home Mixture.....	1.56	.....	1.87	3.43	3.18	6.30	1.17	2.31	9.78	10.46	7.47	7.50	9.11	9.69	8.72	26.79	30.36	6891
7048 McConnell's Home Mixture.....	.....	0.37	5.42	5.79	†	2.16	3.19	2.36	7.71	†	5.35	†	7.07	†	7.49	29.48	33.00	7048
7111 Nicholson's Home Mixture.....	1.03	1.72	0.66	3.41	3.53	3.66	1.67	1.01	11.34	11.47	10.33	10.08	4.50	9.00	4.68	25.61	26.47	7111
7279 Warbase's Home Mixture.....	2.07	.....	1.62	3.69	3.56	5.74	0.18	0.24	6.16	.....	5.92	4.00	19.49	19.00	20.01	34.28	31.46	7279
7468 Bray's Home Mixture.....	.....	.....	2.51	2.51	2.42	0.86	5.66	4.40	10.92	.....	6.52	7.52	10.51	10.00	10.64	25.43	18.79	7468
7794 Gloucester County Grange Mixture.....	.....	1.57	2.24	3.81	3.48	3.06	2.97	2.87	8.90	9.50	6.03	4.50	9.37	8.75	5.12	\$27.26	\$27.00	7794
7795 " Sweet Potato Fertilizer.....	.....	0.28	1.84	2.12	2.05	4.10	1.87	5.45	10.92	9.00	5.47	4.00	8.50	10.00	5.02	22.03	24.74	7795
7484 Haganan's Mixture.....	.....	.....	1.86	1.86	2.46	4.16	4.43	7.26	15.85	10.00	3.59	.....	9.46	10.00	9.20	26.07	22.00	7484

* Guarantee calculated. † Ingredients were not analysed or guaranteed.

7043. Mixed by Tobias McConnell, Smith's Landing. Consists of 187 pounds of dried and ground fish, 94 pounds of ground bone and 75 pounds of muriate of potash.

7111. Mixed by I. W. Nicholson, Camden. Consists of 200 pounds of nitrate of soda, 200 pounds of sulphate of ammonia, 800 pounds of dissolved bone black, 600 pounds of dissolved South Carolina rock and 200 pounds of muriate of potash.

7279. Mixed by Dayton N. Warbasse, Huntsburg. Consists of 274 pounds of nitrate of soda, 206 pounds of dried blood, 760 pounds of dissolved bone black and 760 pounds of muriate of potash.

7468. Mixed by S. V. Bray, Holmdel. Consists of 1,600 pounds of dissolved bone and tankage and 400 pounds of muriate of potash.

An examination of the analyses shows that the mixtures were, on the whole, of the composition intended. The home mixing of fertilizers presents the intimately-related advantages of a definite knowledge of the kind and form of plant-food contained, and the possibility of suiting the formula to the particular needs of the soil and crop. The average estimated valuation is \$28.34, while the average cost is \$26.18, indicating a saving on the part of the consumer not only of the difference, \$2.16, but also of the additional expenses involved, which would have been paid if the *average* commercial mixture had been purchased.

Special Mixtures.

The two samples **6794** and **6795**, whose analyses are in the same table as the home mixtures, are mixtures specially prepared by the Moro Phillips Chemical Co. for the Gloucester County Grange, and indicate what can be secured from the regular manufacturers in car-load lots for cash. These were bought mixed and under guarantee, and the prices given include the freight. Sample No. **7484** is a mixture of 800 pounds of ground bone, 800 pounds of dissolved bone and 400 pounds of muriate of potash. It was prepared to order for Mr. Joseph Hagaman, Oakdale, by The Taylor Provision Co. through a local dealer. The price, therefore, includes the expenses of its sale.

A large and growing number of dealers also are buying fertilizers mixed to order by the larger manufacturers, which they sell under their own name in their own locality. The analyses of these are

published with the regular commercial brands. The majority of them are sold quite as cheap as the regular brands and yield the dealers a fair profit. This profit can be secured directly by the farmers themselves by co-operation and cash purchases whereby carload rates may be secured.

This work of the Experiment Station teaches the very important lesson that a pound of any one of the constituents in its original form is practically uniform in price to all manufacturers, and the subsequent variations in price are due to conditions that occur after leaving the hands of the manufacturer and before reaching the consumer, and for which the consumer is largely responsible. If the latter knows what he wants, buys what he needs and pays cash, he will find that the cost of plant-food will be considerably reduced, and that too without any detriment to the manufacturer. Farmers must remember that—

1. Fully one-fourth of the cost of the average commercial mixture goes to pay for mixing, bagging, credit and commissions.
2. That this amount may be reduced very materially by the use of business-like methods of purchase.

4.

THE EXAMINATION AND VALUATION OF MANUFACTURED BRANDS AND SUNDRY MATERIALS.

On the following pages are reported the analyses of :

331	samples	of	Complete Fertilizers,
32	"	"	Ground Bone,
20	"	"	Miscellaneous Fertilizers,
8	"	"	Wood Ashes, and
11	"	"	Sundry Materials.

The main object of this work is to determine by chemical analysis whether the *actual* composition of each of these various manufactured products corresponds with its *guaranteed* composition, as required by law. By a comparison of the two it is shown whether the manufacturer fulfills his claims and how far the guarantee given is a guide as to the amounts of plant-food actually delivered to the consumer. In addition, the application of the Station's schedule of values, which has been adopted for the various kinds and forms of fertilizer constituents

and is published on a previous page, demonstrates whether the selling prices are justified and the amounts by which they exceed the commercial values derived from the analyses represent the charges of the different manufacturers for mixing and bagging their goods and effecting their sale.

This work is of direct value to the intelligent and experienced purchaser in furnishing definite information relative to the composition and value of the different brands to which his attention may be called; and is of indirect value to all purchasers in reducing to a minimum the amount of worthless material offered for sale.

1. Complete Fertilizers.

The number of samples of complete fertilizers examined this year is greater than ever before, exceeding last year by 60. This is due both to an increase in the number of manufacturers and to a multiplication of brands. For, in the first place, while 11 manufacturers represented in 1895 by 19 brands are not represented this year by any, there are 27 whose names did not appear last year, who are represented in this report by a total of 59, making a net increase of 40 brands and 16 manufacturers. In the second place the representation of those manufacturers whose names appear both years is increased in 24 cases by a total of 55 samples and decreased in 19 cases by only 35, or a net increase of 20. Although it may be advisable to have on sale a variety of brands differing in composition, in order to offer the purchaser a range of choice, the extent to which this has been carried in some cases would seem of doubtful utility.

In the tables of analyses there may be found four manufacturers each represented by twelve or more brands, 3 by from ten to twelve, and 17 by between five and ten, and in some instances the difference seems to be entirely in the name, depending upon the particular stencil which has been used to brand the bags.

Brand Names.

The 331 samples whose analyses are here reported are on the whole of good quality and for the most part furnish plant-food in quickly-available forms. Among them is found almost every practicable amount and proportion of the several ingredients, nitrogen ranging

from 0.21 to 8.35 per cent., available phosphoric acid from 2.72 to 12.83 per cent. and potash from 0.71 to 17.37 per cent. With few exceptions the names of these materials give no indications either of the amount of plant-food contained or of the ingredients of the mixture. The brand name "Harvest Queen," for example, which is used by three different manufacturers, gives no clue to the composition of that brand; nor does "Potato Fertilizer," "Corn Manure," etc., since manufacturers by no means agree as to the amounts and proportions of plant-food required by these crops; and the designation of a material as a "Dissolved Bone Phosphate" does not necessarily imply that a trace of bone has been used in its preparation.

In addition there are about 30 brands with names like "Ammoniated Bone Phosphate," "Pure Bone Superphosphate," etc., which in no way indicate the potash salts which are present in all of them, and in 14 of these a consideration of the brand name alone would result in their being mistaken for pure bone meal.

The necessity may be seen, therefore, of the published statement of analysis or guaranteed composition of each brand, which is required by law, and the importance of a conformity of the actual composition with it.

Guaranteed and Actual Composition.

In two cases the brands analysed this year have not been accompanied by a published guarantee; one is exempt from this requirement by virtue of being an imported guano; in the case of the other, No. 7265, "Crude Fish and Tobacco Stems," the manufacturer is remiss. Notwithstanding the fact that the material may happen, as in this case, to be worth, as complete fertilizers sell, about what is charged for it, consumers should insist upon compliance with this requirement of the law before they consent to purchase.

A careful comparison of the actual composition of the remaining 329 brands with their accompanying guarantees shows that more than four-fifths of them contain as much total plant-food as is claimed. In many cases, however, it is not distributed in the proportions which are stated.

The following table shows the number of brands deficient in one or more of the plant-food constituents compared with the same for 1895. In compiling this table any brand that failed to reach its guarantee of nitrogen by only 0.20 per cent., or its guarantee of phosphoric acid or potash by only 0.30 per cent., has not been included.

	Brands examined.	Found as guaranteed.	Found deficient.	Number of Deficiencies.		
				Nitrogen.	Phosphoric Acid.	Potash.
1895.....	269	158	111	17	72	37
1896.....	329	211	118	30	52	56

As indicated by the table, there has been a further improvement in the keeping of guarantees in the case of phosphoric acid, in which the chief difficulty in this respect has seemed to be in the past. This improvement, however, has been to the disadvantage of the other constituents but not to such an extent as to cause it to disappear in a consideration of the general result. In 1896 over 64 per cent. of the brands reach or exceed their guarantees in all particulars, as compared with not quite 59 per cent. in 1895. The 138 deficiencies in 1896 occur in 118 brands, 16 being below in two, and 2 in all three of the forms of plant-food. Of the 100 that are below in one and the 16 that are below in two particulars, 64 and 2 respectively have this deficiency made up by exceeding their guarantee in other respects, showing a lack of skill or of carefulness in their preparation rather than an intent to defraud.

Nevertheless, a strict conformity of composition with guarantee is important, since the object of the guarantee is to indicate to the purchaser the proportion, as well as the amount, of the plant-food contained in the brand. Let us suppose that a farmer buys a special fertilizer for potatoes, or other crop, because he believes from experience and experiment that certain proportions of plant-food constituents are better than others. He must trust to the guarantee for guidance in this respect; if the actual composition does not correspond to the guarantee in the proportion of the constituents, his results in the field may be quite as disappointing as if he had received less plant-food than he expected.

From the standpoint of economical purchase, however, the fact that the brand does contain the amount guaranteed does not of itself recommend the brand, since there is no obligation upon the manufacturer to fix his selling price in accordance with the amount of plant-food he offers for sale.

Station's Valuations and Selling Prices.

The Station's valuation per ton is derived by applying to the different constituents the schedule of prices already published; it is intended to show the retail cash cost of the amount of nitrogen, phosphoric acid and potash contained in one ton if they were bought at factory in the form of raw materials, unmixed. The difference between selling price and Station's value shows, therefore, the charges that are made for mixing, bagging, shipping and selling the different brands.

The selling price per ton entered in the tables is the price at the point where sampled. These prices differ in the various localities of the State, due mainly to differences in freight rates from point of production to consumers' depot, the amount sold and commission charged.

In certain States a definite though arbitrary sum for these charges is fixed by the Station and added to the valuation. This method has not been adopted here, since the only effect is to reduce the difference between valuation and selling price. Farmers know what is a fair charge for freight from shipping points to their localities, and can make such calculations themselves, with the further advantage that they apply to their own conditions.

The average composition, estimated value and selling price of all the brands of complete commercial fertilizers examined have been averaged each year for the past six years, and, together with the actual and the percentage difference by which the selling price exceeds the valuation, are shown in the following tabulation :

	Total Nitrogen.	Total Phos. Acid.	Available Phos. Acid.	Insoluble Phos. Acid.	Potash.	Station's valuation.	Selling price.	Actual difference.	Percentage difference
1891.....	2.71	10.12	7.59	2.83	4.21	\$25.31	\$34.23	\$8.92	35.2
1892.....	2.74	10.38	7.70	2.67	4.50	25.66	34.19	8.53	33.2
1893.....	2.69	10.23	7.54	2.69	4.58	24.41	34.11	9.70	39.7
1894.....	2.87	10.40	7.37	3.03	4.94	24.83	34.17	9.34	37.6
1895.....	2.80	10.74	7.84	2.90	4.80	24.15	32.87	8.72	36.1
1896.....	2.51	10.86	8.21	2.65	5.02	21.70	30.33	8.63	39.8

It will be observed that notwithstanding a slight tendency towards furnishing larger amounts of phosphoric acid and potash, the composition of the average fertilizer has been remarkably uniform for the past six years, approximating to the following analysis :

Nitrogen.....	2½ per cent.
Equal to Ammonia.....	3 " "
Phosphoric Acid, total.....	11 " "
" " available.....	8 " "
Actual Potash.....	5 " "
Price.....	\$30.00.

The Station's valuation, however, is lower than ever before, owing to the reductions in the schedule, corresponding to the decrease in the cost of fertilizer supplies. This has been followed by a corresponding reduction in the price, so that the average charges for mixing, bagging, shipping and selling remain still about \$8.50 per ton. On account of the reductions in original cost, however, this amount appears as a much larger percentage difference than ever before, showing that the charges referred to are about the same whatever their original cost may be, and consequently is an argument in favor of the purchase of high-grade goods.

The Purchase of Fertilizers.

In addition to the many *uncertainties* upon which success in agriculture depends, the prices received for the various products are low, leaving the farmer a very narrow margin for the legitimate expenses of growing, handling and selling his crops. Nevertheless, even under these conditions, it is advisable to increase the productive power of the soil to a maximum, which in this State demands a liberal supply of plant-food. Consequently, savings in the cost of this supply that *are certain* and within the power of any farmer to secure are doubly important and in the interest of wise economy should be carefully considered, for it is a recognized truth that a reduction in the cost of producing any article of commerce is more than equivalent to an increase in the amount received from its sale. Farmers may accomplish this reduction of expense by (1) a rational use of natural supplies, and (2) by good business methods in the purchase of the artificial fertilizers.

1. A rational use of natural supplies involves a careful saving and intelligent application of the manures of the stock kept upon the farm, the enrichment of this manure by the use of concentrated feeds rich in the fertilizing constituents, the judicious sale of farm produce with reference to its fertilizer content, and the sowing of large areas of leguminous crops, which secure from the air the expensive element nitrogen, for which in complete fertilizers farmers pay two and one-

half to three times as much as for potash or available phosphoric acid. As suggested in previous reports and bulletins, crimson clover, which does not interfere with regular rotations, and which may be sown under a wide variety of conditions, is a valuable crop for this purpose.

2. As already stated, the average fertilizer has a valuation of \$21.70 per ton, and sells for \$30.33, the difference, \$8.63, representing the average expenses for mixing, bagging, shipping and selling a ton of the material. Good business methods of purchase are all that is needed to effect a legitimate reduction in this amount.

Among the 331 brands from which the above average figures are derived there are abundant *opportunities* for an advantageous purchase. There are 56, or one-sixth of the number of brands which approximate this average difference between valuation and selling price; and while 52 have a difference of from ten to twelve dollars, 43 from twelve to fourteen, 31 from fourteen to sixteen and 4 from sixteen to eighteen, a total of 130 brands, on the other hand, there are 145 with less than the average difference, viz., 53 have a difference of from six to eight dollars, 58 from four to six dollars, 20 from two to four dollars and 14 have a difference still less than this, including 7 whose valuation is greater than the selling price.

The *possibilities* for an advantageous selection from all of these under the present methods of purchase is difficult, since, in so many cases, the guarantee is not a guide to the actual composition, and therefore does not show the plant-food actually valued in the above comparisons. It has already been shown that about 116 of the 331 brands analysed this year do not reach their guarantees in some particular, and 50 of them do not furnish an equivalent of plant-food. On the other hand, there are many brands which furnish plant-food in considerable excess of their guaranteed amounts, and thus receive higher valuations than the latter would lead one to expect. Of the 95 brands whose valuation approaches within \$6 of the selling price, in fully one-half it would not do so if they contained only the guaranteed amounts. The disadvantages of this to a prospective purchaser seeking the most for his money may be illustrated by supposing that three samples which have been analyzed this year have been submitted to him for his selection. The guarantees of ammonia, available phosphoric acid and potash are in the first 1, 8 and 6 per cent., respectively, in the second, 2½, 9 and 3, and in the third, 2, 9 and 6. A rough calculation, using the Station's schedule of prices, indicates that these amounts of plant-food would have a

commercial value of about \$17, \$19 and \$21, respectively ; the selling prices are \$25, \$25 and \$30. Since the price of the third material sells for \$9 more than its valuation, it is thrown aside, and of the other two, which sell for the same price, the second is selected, since it offers the greater amount of plant-food. The actual analyses of these materials, however, show that the purchaser has chosen the poorest of the three. Instead of showing a commercial value of \$17, \$19 and \$21, respectively, as indicated by the guarantees, they actually show \$26, \$18 and \$25. The other \$25 fertilizer should have been taken, or even the \$30 material, for instead of charging \$9 for mixing and other expenses it only charges \$5, while the material which was chosen as seemingly charging \$6, actually charges \$9, and that too for mixing materials which in this instance are not of as good quality as the other two.

To overcome these difficulties farmers are recommended to change their method of purchase. Fertilizers should not be bought as so many tons of fertilizer, but as a material containing in each ton so many pounds of nitrogen (or ammonia), available phosphoric acid and potash, for a deficiency in the amount of which a financial reparation is to be made. The best method of doing this is to buy on what is known as the "unit system." This was suggested last year, but its great advantages warrant the Station in again urging its use.

The "unit" is 20 pounds of actual plant-food. A fertilizer containing 2 per cent. of ammonia, 8 per cent. of available phosphoric acid and $1\frac{1}{2}$ per cent. of potash would contain 40 pounds of ammonia, 160 pounds of available phosphoric acid and 30 pounds of actual potash in every ton, and therefore contains 2, 8 and $1\frac{1}{2}$ units, respectively, of each of these kinds of plant-food. In other words, since there are twenty hundredweight in a ton, the figures of the analysis which show the number of pounds in a hundredweight, also show the number of units in a ton.

The "unit system" of purchase consists in paying for what the mixture actually contains, at a definite rate or price per unit ; in other words, pay for what you get and get what you pay for. This would require an analysis to determine the number of units contained. When agreements are made in this manner, and twenty tons or more are purchased, the Experiment Station will make this analysis free of charge, provided it receives the full information respecting the transaction which it is required to have in all cases. A number of manufacturers have signified their willingness to sell on this plan,

and it is quite likely that all would do so, since it is eminently fair to both parties in the transaction, and because manufacturers now buy their supplies on this basis.

Unit prices corresponding to the ton price of the average fertilizer this year would be \$3.90 for nitrogen (equal to \$3.20 for ammonia), \$1.75 for available phosphoric acid, and \$1.25 for potash. *Those farmers who study the conditions of the market, make up their orders early and by combining with others purchase in considerable quantities and for cash, will undoubtedly secure better quotations than these, while those who buy at the busiest season of the year, in small lots at a time, upon long credit and of the nearest dealer, will have to pay for the accommodations thus afforded.*

2. Ground Bone.

The 32 samples of ground bone examined this year on the whole reach their guarantees, show a good degree of fineness, and with a few exceptions, a relatively high valuation when compared with complete fertilizers. A large number of samples consist of what is known as "steamed bone" and in these the content of nitrogen is much lower, and that of phosphoric acid much higher than the average. The sample most pronounced in this respect, No. 7025, contains only 1.63 per cent. of nitrogen and 30.56 per cent. of phosphoric acid. The steaming of bone removes glue, grease and other animal matter to such an extent that the residue is in this case nearly two-thirds pure phosphate of lime. Consumers who buy this kind of bone for the first time often have unjust suspicions unnecessarily aroused, since the material is usually very fine, and therefore packs closer in the bag than raw bone, and by losing its porous bony structure to a large degree, has assumed the appearance of being mixed with mineral matter.

On the other hand, there are many samples which have their proportions of nitrogen and phosphoric acid, relative to average bone, exactly reversed, the phosphoric acid falling nearly as low as 20 per cent., accompanied by about 4 per cent. of nitrogen.

These facts are pointed out, not to condemn or criticise the samples mentioned, since they are substantially as guaranteed, and at the prices asked are economical sources of plant-food, but to show that "ground bone," as found on the market, is a variable product, in the purchase of which guarantees must be studied. According to the analyses and

selling prices of the samples published herewith, average bone contains 3.43 per cent. of nitrogen and 24.53 per cent. of phosphoric acid, and sells for \$23.07 per ton. Any variation in the guarantee from this amount of nitrogen should have a compensating variation in the guaranteed amount of phosphoric acid or in the price.

Of the 32 samples reported, 5 were not accompanied by any guarantee as required by law. With perhaps one exception, however, these represent local products limited in quantity, and in every case except sample No. 7425 the actual analysis was found to warrant the selling price. Of the remaining 27, 20 agree with their guaranteed composition, and 7, while not corresponding exactly, nevertheless furnish an equivalent of plant-food claimed.

Valuation of Bone.

The schedule of prices used in computing values in 1895 and 1896 and the average per cent. of fineness of the bone are shown below :

	Average per cent. of Fineness.		Nitrogen Per Pound.		Phosphoric Acid Per Pound.	
	1895.	1896.	1895.	1896.	1895.	1896.
Finer than $\frac{1}{30}$ in.....	46	53	16c.	13½c.	5½c.	5c.
" " $\frac{1}{25}$ "	25	22	14c.	12c.	4½c.	4c.
" " $\frac{1}{20}$ "	21	20	11c.	9c.	3c.	2½c.
Coarser than $\frac{1}{15}$ "	8	5	5c.	3c.	2c.	2c.

The samples examined this year are finer on the average than those of last year, which were themselves finer than those of 1894. The schedule of prices this year is lower throughout except in the case of phosphoric acid in the coarsest grade. Nevertheless, the average Station's value of the samples analysed is more than five dollars higher than the average selling price, which would indicate that on the whole the nitrogen and phosphoric acid contained in bone are obtained at the prices per pound indicated in the schedule.

3. Miscellaneous Fertilizers.

Fifteen of the 20 samples of miscellaneous fertilizers represent materials furnishing either nitrogen and phosphoric acid or phosphoric acid and potash, and are grouped together according to this classification. They consist either of true dissolved bone or of plain superphosphate of lime with ammoniates or potash salts added; the other five samples are plain superphosphates of lime furnishing avail-

able phosphoric acid, and are in a separate group. As in the case of complete fertilizers, the brand names of many of these materials are misleading. Four samples branded "Soluble Bone," "Soluble Bone Phosphate," "Dissolved Bone and Potash" and "Alkaline Bone No. 2," respectively, contain no animal bone as such. In addition, the latter two, together with two others branded "Union Fresh Ground Bone" and "Animal Bone," give no indication in their title that, contrary to what would be expected from pure animal bone, a portion of their phosphoric acid is soluble in water. Freedom in the use of these materials as if they were pure bone might result in injury to the plants to which they are applied. This fact emphasizes the necessity of a careful inspection of the guarantee, which in these cases discloses their character at once.

A comparison of the actual with the guaranteed composition and of the Station's valuation with the selling price, shows that the samples are on the whole of fairly good quality, but that half of them are relatively expensive fertilizers.

4. Wood Ashes.

Only three samples of wood ashes have been received this year. They show the usual wide variation in composition. The schedule prices are for phosphoric acid four and one-half cents per pound and for potash five cents per pound, these alone being considered in estimating the valuation. On this account wood ashes appear as expensive sources of plant-food. The favorable physical effect which follows the use of wood ashes is well known, however, and is undoubtedly due to the five to eight hundred pounds per ton of lime it contains in an air-slaked condition. To farmers who desire to apply lime, wood ashes have an increased value, determined by the price at which they can purchase the lime in other forms in their own neighborhood. This being variable, the Station does not include it in its estimated valuation.

5. Sundry Materials.

The eleven sundry materials, whose analyses are reported, consist mainly of waste products which were examined to determine their possible development as sources of plant-food. With one exception no valuation is affixed, on account of lack of data whereby a fair allowance of value may be determined.

Complete Fertilizer's
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
7287	Potato and Truck.....	J. H. Allen, Lawrence Station, N. J.	J. M. Dalrymple, Hopewell.	7287
7288	Special Potato.....	" " " "	" " " "	7288
7288	Ammoniated Dissolved Bone.....	" " " "	" " " "	7288
7012	Special Potato Fertilizer.....	Warren Atkinson, Mullica Hill, N. J.	J. C. Griscom, Woodbury.	7012
7013	Sweet and White Potato Fertilizer.....	" " " "	" " " "	7013
7019	Lawn Dressing.....	H. J. Baker & Bro., New York City.	D. N. Warbasse, Hantsburg.	7019
7181	Special Potato Manure.....	" " " "	T. F. Baker, Bridgeton.	7181
7249	Potato Manure.....	" " " "	J. M. White, New Brunswick	7249
7250	Standard UXLD.....	" " " "	" " " "	7250
7353	"A A" Ammoniated Superphosphate.....	" " " "	W. E. Ward, Lyons Farms.	7353
7342	Special Corn Manure.....	" " " "	B. F. Ward, Hainesburg	7342
7343	Vegetable, Vine and Potato.....	" " " "	" " " "	7343
7377	Harvest Home.....	" " " "	J. J. Mitchell, Troy Hills.	7377
7180	Special Potato Manure.....	Baugh & Sons' Co., Philadelphia, Pa.	T. F. Baker, Bridgeton.	7180
6914	\$25 Phosphate.....	" " " "	H. I. Budd, Mount Holly.	6914
6916	Bone and Potash Compound.....	" " " "	" " " "	6916
7064	General Crop Grower.....	" " " "	" " " "	7064

Complete Fertilizer's
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	Nitrogen.						Phosphoric Acid.				Potash.		Chlorine.	Value of 2,000 lbs. at Stations' Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.			
	From Nitrates.			From Ammonia Salts.			Total Found.		Total Guaranteed.		Available.	Found.					Guaranteed.		
	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Citrate.	Insoluble.	Total Found.	Guaranteed.											
7287	Allen's Potato and Truck.....	1.78	.....	1.75	3.53	3.28	3.96	2.42	3.30	9.68	.....	6.38	7.00	9.77	10.00	9.28	\$26.84	\$35.00	7287
7286	" Special Potato.....	1.66	.....	1.52	3.18	3.28	7.20	1.23	1.18	9.61	.....	8.43	8.00	10.30	10.00	7.81	27.75	35.00	7286
7285	" Ammoniated Dissolved Bone.....	0.50	.....	1.17	1.67	1.64	3.28	4.19	5.33	12.80	10.00	7.47	8.00	2.30	2.00	2.29	17.05	23.00	7285
7012	Atkinson's Special Potato.....	0.73	1.05	2.06	3.84	3.69	5.32	3.69	2.76	11.77	10.00	9.01	7.00	7.57	7.00	7.17	28.71	34.00	7012
7013	" Sweet and White Potato.....	0.80	0.20	2.15	3.15	2.46	5.30	3.11	3.63	12.04	10.00	8.41	7.00	7.92	7.00	7.66	26.61	29.00	7013
7019	Baker's Lawn Dressing.....	1.20	1.40	1.27	3.87	3.49	3.80	2.30	1.19	7.29	.....	6.10	4.25	7.32	7.00	9.52	24.78	42.00	7019
7181	" Special Potato.....	0.64	.....	1.18	1.82	1.64	4.67	1.30	0.41	6.38	.....	5.97	5.00	10.25	10.00	12.88	20.99	30.00	7181
7249	" Potato Manure.....	0.52	1.38	1.82	3.67	3.28	4.72	1.99	0.66	7.37	6.75	6.71	5.75	10.77	10.00	3.00	28.50	39.00	7249
7250	" Standard UsXLD.....	0.42	0.55	1.28	2.25	2.05	4.80	5.01	1.46	11.27	.....	9.81	8.00	2.90	2.25	5.56	20.34	31.00	7250
7353	" "AA" Ammoniated Superphosphate.....	0.38	1.30	1.29	2.97	2.46	7.83	3.79	0.84	12.46	11.00	11.62	10.00	2.88	2.00	3.78	24.25	32.00	7353
7342	" Special Corn Manure.....	0.21	2.97	1.35	4.53	4.10	4.60	2.65	0.95	8.20	7.00	7.25	6.50	7.49	7.00	9.23	28.36	40.00	7342
7343	" Vegetable, Vine and Potato.....	.....	0.77	1.14	1.91	1.64	4.78	1.58	0.64	7.00	6.50	6.36	5.50	12.26	12.00	4.01	24.49	35.00	7343
7377	" Harvest Home.....	.....	0.39	1.18	1.57	1.03	3.34	2.41	1.93	11.51	9.00	9.58	8.00	2.71	2.00	6.25	18.21	27.50	7377
7180	Baugh's Special Potato.....	.....	.....	2.01	2.01	1.64	4.76	0.61	2.89	8.26	7.50	5.37	5.00	10.20	10.00	5.74	22.14	30.00	7180
6914	" \$25 Phosphate.....	0.23	0.24	2.04	2.51	2.05	7.00	0.96	3.64	11.60	.....	7.96	7.00	0.87	0.50	1.14	18.05	25.00	6914
6916	" Bone and Potash.....	.....	.....	2.04	2.04	1.64	6.92	1.51	3.09	11.52	10.50	8.43	8.00	1.68	2.00	2.87	17.73	26.00	6916
7064	" General Crop Grower.....	.....	.....	1.36	1.36	0.82	7.36	0.90	2.84	11.10	.....	8.26	8.00	1.35	1.00	5.07	15.26	20.00	7064

Complete Fertilizers.

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
6928	Electric Special \$25 Bone Manure.....	The Berg Co., Philadelphia, Pa.	H. I. Budd, Mount Holly.	6928
6929	" Special Potato Gusano.....	" " "	" " "	6929
7200	" " \$30 Cyclone Bone Manure.....	" " "	A. Dilts, Copper Hill.	7200
7296	" " \$35 Potato Manure	" " "	J. M. Dalrymple, Hopewell.	7296
6966	Pure Dissolved Bone and Potash	" " "	C. Kraus, Egg Harbor City.	6966
6965	Potato and Vegetable.....	Bowker Fertilizer Co., New York City.	D. C. Crane, Westfield.	6965
6968	Lawn and Garden Dressing.	" " "	" " "	6968
6799	Market Garden	" " "	J. H. Denise, Freehold.	6799
7178	Sure Crop Phosphate.....	" " "	T. F. Baker, Bridgeton.	7178
7254	Stockbridge Potato and Vegetable.....	" " "	J. M. White, New Brunswick.	7254
7253	Ammoniated Dissolved Bone.....	" " "	" " "	7253
7854	Stockbridge Top Dressing.....	" " "	W. R. Ward, Lyons Farms.	7854
7855	Hill and Drill.....	" " "	" " "	7855
6980	Fish and Potash.....	" " "	H. I. Budd, Mount Holly.	6980
6983	Sweet Potato and Truck	" " "	" " "	6983
6977	Union High Grade.....	" " "	C. Kraus, Egg Harbor City.	6977

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	Nitrogen.										Phosphoric Acid.						Potash.		Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
	From Nitrates.				Total Guaranteed.		Soluble in Water.		Insoluble.	Total Found.	Total Guaranteed.	Available.		Round.	Guaranteed.							
	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Ammonium Citrate.	Round.	Guaranteed.															
39928	Berg's Electric Special \$25 Bone.....	.....	2.02	2.02	1.64	3.46	4.01	4.31	11.78	9.00	7.47	7.00	3.02	2.00	8.20	\$18.32	\$25.00	6928				
39929	" " " Potato.....	1.42	.....	2.60	3.92	3.28	5.24	2.87	2.70	10.81	8.11	8.00	10.20	8.00	8.16	30.01	36.00	6929				
7200	" " " \$30 Cyclone Bone.....	.....	2.92	2.92	2.46	3.90	3.91	4.09	11.90	9.00	7.81	7.00	4.01	3.00	6.09	22.02	28.00	7200				
7296	" " " \$35 Potato.....	0.96	0.28	2.84	4.08	2.46	3.88	3.76	4.26	11.90	9.00	7.00	9.13	8.00	7.40	29.71	35.00	7296				
6866	" Pure Dissolved Bone and Potash.....	.....	2.84	2.84	2.46	2.98	6.23	7.29	16.50	.....	9.31	9.00	3.83	3.50	5.48	23.05	31.00	6866				
6965	Bowler's Potato and Vegetable.....	1.00	.....	1.58	2.58	2.46	4.80	2.70	3.55	11.05	7.50	8.00	4.02	4.00	8.99	20.41	33.00	6965				
6968	" Lawn and Garden Dressing.....	4.07	.....	0.56	4.63	3.28	0.44	5.70	2.53	8.67	6.14	6.00	5.99	5.00	5.18	25.71	40.00	6968				
6799	" Market Garden.....	1.20	.....	1.48	2.68	2.46	6.16	0.94	4.82	11.92	7.10	6.00	9.78	10.00	9.68	25.92	37.00	6799				
7178	" Sure Crop Phosphate.....	0.27	.....	0.79	1.06	0.82	3.40	4.89	4.79	13.08	8.29	8.00	1.38	1.00	1.48	15.22	24.00	7178				
7254	" Stockbridge Potato and Vegetable.....	1.41	.....	1.91	3.35	3.28	4.00	1.45	4.40	9.85	5.45	5.00	10.39	10.00	10.06	26.35	38.00	7254				
7283	" Ammoniated Dissolved Bone.....	0.64	.....	1.19	1.83	1.64	3.60	3.70	5.52	12.82	7.30	8.00	2.51	2.00	2.58	17.56	28.00	7283				
7354	" Stockbridge Top Dressing.....	6.14	.....	0.88	7.02	4.92	3.28	0.99	1.83	6.10	4.37	4.00	5.20	6.00	4.76	29.15	40.00	7354				
7855	" Hill and Drill.....	0.77	.....	1.98	2.70	2.46	9.00	0.87	2.41	12.28	10.00	9.87	2.41	2.00	2.31	21.47	27.00	7855				
6880	" Fish and Potash.....	.....	.....	2.72	2.72	2.46	3.28	1.23	4.19	8.70	4.51	.....	4.19	4.00	10.29	18.03	29.00	6880				
6833	" Sweet Potato and Truck.....	0.62	.....	1.89	2.01	1.64	3.10	3.92	3.45	10.47	8.00	7.02	8.95	8.00	8.72	22.72	30.00	6833				
6877	" Union High Grade.....	1.80	.....	2.11	3.41	3.28	6.60	1.06	3.14	10.80	7.00	7.66	6.85	7.00	6.45	25.28	35.00	6877				

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
7271	Corn Manure.....	Bowker Fertilizer Co., New York City.	D. N. Warbasse, Hantsburg.	7271
7879	Root Fertilizer.....	" " " "	J. J. Mitchell, Troy Hl.s.	7879
7022	Complete for Potatoes and Vegetables.....	Bradley Fertilizer Co., Boston, Mass.	D. N. Warbasse, Hantsburg.	7022
7021	Patent Superphosphate.....	" " " "	" " "	7021
7020	New Method Fertilizer.....	" " " "	" " "	7020
7023	Potato Manure.....	" " " "	" " "	7023
7024	Ground Bone with Potash.....	" " " "	" " "	7024
7186	Diamond Sweet Potato, Fruit and Vine.....	E. G. Brick, Penn Grove, N. J.	W. Pettit, Salem.	7186
7186	" High-Grade Potato Manure.....	" " " "	" " "	7186
6879	Potato Phosphate.....	Brunfield & Foster, Colors, Md.	C. Kraus, Egg Harbor City.	6879
6880	Sweet Potato, Fruit and Vine Grower.....	" " " "	" " "	6880
6882	Ammoniated Bone Phosphate.....	" " " "	" " "	6882
6883	Raw Bone and Potash.....	" " " "	" " "	6883
7182	Ten Per Cent. Potato Fertilizer.....	Chandler, Russell & Chandler, Newark, N. J.	T. F. Baker, Bridgeton.	7182
7226	Special.....	" " " "	J. H. Denise, Freehold.	7226
7288	Standard Pure Bone Superphosphate.....	" " " "	J. M. Dalrymple, Hopewell.	7288

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	Nitrogen.						Phosphoric Acid.						Potash.		Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
	From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available.		Guaranteed.				
											Found.	Guaranteed.					
														Found.				Guaranteed.
7771	1.77	.....	1.76	3.53	3.28	7.18	1.29	3.66	12.13	10.00	8.47	8.00	4.82	4.00	324.83	338.00	7271
7879	3.54	.....	1.19	4.73	4.00	4.74	1.27	2.27	8.28	10.00	6.01	7.00	7.23	4.00	26.93	36.00	7879
7022	0.91	0.03	2.03	3.57	3.69	5.02	2.86	3.91	11.79	9.00	7.88	8.00	6.47	6.00	26.08	37.00	7022
7021	0.50	.....	2.20	2.70	2.46	6.94	2.00	2.55	11.49	11.00	8.94	9.00	3.44	2.00	20.56	33.00	7021
7020	.....	.....	2.25	2.25	1.64	6.58	2.31	3.03	11.92	10.00	8.89	8.00	1.75	3.00	25.2	33.00	7020
7023	0.59	.....	1.92	2.66	2.46	6.80	1.98	2.92	8.70	8.00	5.78	6.00	5.68	5.00	20.61	33.00	7023
7024	0.57	.....	1.07	2.49	1.85	4.50	1.49	6.74	12.73	10.00	5.99	6.00	2.97	2.00	0.61	31.00	7024
7135	0.46	0.65	1.66	2.77	2.46	0.96	5.03	3.64	9.63	.....	5.99	7.00	7.22	9.00	22.39	27.50	7135
7136	0.35	0.50	2.44	3.29	3.28	3.64	4.33	1.64	9.61	.....	7.97	8.00	6.04	6.00	24.14	30.00	7136
6879	.....	.....	1.17	1.17	0.82	5.92	1.35	1.72	8.99	8.00	7.27	7.00	4.68	5.00	16.18	25.00	6879
6880	.....	0.22	1.84	2.06	2.05	6.07	1.95	1.52	9.54	9.00	8.02	8.00	9.25	8.00	23.58	35.00	6880
6882	.....	0.25	1.75	2.00	1.64	6.77	1.91	1.57	10.25	10.00	8.68	9.00	4.05	2.00	19.48	26.00	6882
6883	.....	.....	2.50	2.50	2.05	.....	8.13	8.43	16.56	11.25	8.13	.....	3.54	4.00	21.60	31.00	6883
7182	0.35	0.41	1.17	1.93	1.64	2.26	5.69	3.67	11.62	.....	7.95	8.00	10.27	10.00	24.92	30.00	7182
7226	1.23	0.41	1.09	2.73	2.46	6.91	3.94	1.84	12.19	.....	10.85	10.00	4.97	5.00	24.97	27.00	7226
7238	0.62	0.24	1.63	2.49	2.34	4.74	5.77	2.39	12.90	12.00	10.51	10.00	1.59	1.50	20.99	28.00	7238

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
7214	Ammoniated Dissolved Bone Phosphate.....	Chandler, Russell & Chandler, Newark, N. J.	A. Dilts, Copper Hill.	7214
7211	Special Potato Fertilizer.....	" " " " " "	" " " " " "	7211
7215	Special Corn Manure.....	" " " " " "	" " " " " "	7215
6942	Harvest Queen Phosphate.....	" " " " " "	H. I. Budd, Mount Holly.	6942
7255	Potato Manure.....	" " " " " "	J. M. White, New Brunswick.	7255
6988	Champion Manure.....	" " " " " "	D. C. Crane, Westfield.	6988
7857	Lawn Top Dressing.....	" " " " " "	W. R. Ward, Lyons Farms.	7857
6889	Baker's Special Wheat and Grass.....	Chemical Co. of Canton, Baltimore, Md.	C. Kraus, Egg Harbor City.	6889
6888	" Standard Guano.....	" " " " " "	" " " " " "	6888
6894	" Berry Guano.....	" " " " " "	" " " " " "	6894
6901	" Special Wheat, Corn and Oats.....	" " " " " "	" " " " " "	6901
6902	Truckers' Delight.....	" " " " " "	" " " " " "	6902
6884	Special Potato Manure.....	" " " " " "	" " " " " "	6884
6885	Dedance Complete Manure.....	The Clark's Cove Fertilizer Co., New York City.	" " " " " "	6885
6998	Potato Phosphate.....	" " " " " "	" " " " " "	6998
6887	Unicorn Superphosphate.....	" " " " " "	" " " " " "	6887
6886	King Philip Alkaline Guano.....	" " " " " "	" " " " " "	6886

Complete Fertilizers Furnishing Nitrogen, Phosphoric Acid and Potash.

EXPERIMENT STATION REPORT.

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Station Number.		Nitrogen.				Phosphoric Acid.				Potash.		Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.					
		From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.		Insoluble.	Total Found.	Total Guaranteed.				Available.				
							Soluble in Ammonium Citrate.	Soluble in Water.							Round.	Guaranteed.	Round.	Guaranteed.	
7214	Russell's Ammoniated Dissolved Bone.....	0.26	0.28	1.51	2.02	1.80	4.66	5.62	3.21	13.49	11.00	10.28	9.00	2.07	1.50	\$20.26	\$25.00	7214	
7211	" Special Potato.....	.....	0.82	1.42	1.74	1.64	2.90	5.92	4.19	13.01	.....	8.82	8.00	3.17	3.00	0.72	19.40	25.00	7211
7215	" " Corn.....	.....	0.88	1.46	1.79	1.64	2.68	6.21	4.29	13.13	.....	8.84	8.00	3.41	3.00	0.79	19.83	25.00	7215
6942	" Harvest Queen Phosphate.....	.....	0.36	1.06	1.42	1.23	2.41	8.91	3.80	14.62	.....	11.32	9.50	3.27	2.00	2.40	20.76	25.00	6942
7255	" Potato Manure.....	1.57	0.29	0.80	2.66	3.69	8.71	5.93	1.68	11.34	.....	9.66	7.50	8.23	7.00	5.49	26.16	38.00	7255
6938	" Champion Manure.....	.....	0.28	0.75	0.98	0.82	2.91	7.27	3.16	13.34	.....	10.18	8.00	1.98	2.00	2.98	17.03	25.00	6938
7857	" Lawn Top-Dressing.....	0.57	.....	1.93	2.50	2.46	2.98	3.84	1.04	7.36	.....	6.32	5.00	7.41	8.00	0.94	21.60	30.00	7857
6839	Baker's Special Wheat and Grass.....	.....	.....	1.14	1.14	0.82	6.04	2.66	3.81	11.51	.....	7.70	9.00	2.30	2.00	5.98	15.25	25.00	6839
6886	" Standard Guano.....	.....	.....	2.22	2.22	2.05	5.89	2.24	2.78	10.36	.....	7.63	9.00	2.24	2.50	5.23	17.72	30.00	6886
6894	" Berry Guano.....	0.28	0.98	2.57	3.80	4.10	3.84	2.80	2.88	8.97	.....	6.14	6.00	5.00	3.00	12.70	23.19	34.00	6894
6901	" Special Wheat, Corn and Oats.....	.....	1.82	1.32	4.64	4.92	5.18	2.49	3.88	11.50	11.00	7.67	9.00	2.17	2.00	5.46	15.62	25.00	6901
6902	C. C. C.'s Truckers' Delight.....	1.63	3.01	4.64	9.34	4.92	3.98	2.48	2.54	9.00	.....	6.46	8.00	3.44	4.00	6.82	24.55	36.00	6902
6884	" Special Potato.....	.....	1.51	0.88	2.34	2.46	5.97	1.12	0.91	8.00	.....	7.09	6.00	8.72	9.00	8.56	22.86	38.00	6884
6935	Clark's Cove's Defiance.....	.....	1.41	1.41	4.64	4.92	3.44	3.97	2.79	10.20	8.00	7.41	6.00	1.91	2.00	8.41	14.94	34.00	6935
6893	" " Potato Phosphate.....	.....	2.66	2.66	2.46	5.84	1.14	2.84	.....	9.02	7.00	6.68	6.00	5.19	5.00	5.23	20.40	33.00	6893
6887	" " Unicorn Superphosphate.....	0.28	1.62	1.87	1.85	4.83	6.08	2.71	.....	13.07	10.00	10.36	8.50	2.12	2.25	2.27	19.67	30.00	6887
6886	" " King Philip.....	.....	1.47	1.47	1.23	2.24	4.81	3.17	.....	10.22	9.00	7.05	6.00	3.10	3.00	4.39	15.93	28.00	6886

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
6886	Farmers Favorite Vegetator.....	E. A. Clendennin & Bro., Colons Md.	H. I. Budd Mount Holly.	6885
6886	National Standard Ammoniated Phosphate.....	" " " "	" " "	6886
6887	Special Potato and Truck.....	" " " "	" " "	6887
7426	Excelsior Guano.....	E. Frank Coe Co., New York City.	W. R. Ward, Lyons Farms.	7426
6992	" " Red Brand.....	" " " "	J. C. Griscom, Woodbury.	6992
7065	Alkaline Bone.....	" " " "	H. I. Budd, Mount Holly.	7065
7401	Dissolved Bone Phosphate.....	" " " "	J. M. Dalrymple, Hopewell.	7401
6994	High-Grade Fish Guano and Potash.....	" " " "	J. C. Griscom, Woodbury.	6994
6808	Peach Tree Fertilizer.....	" " " "	J. H. Denise, Freehold.	6808
6804	Celebrated Special Potato.....	" " " "	" " "	6804
6806	Excelsior Potato Fertilizer.....	" " " "	" " "	6806
7844	High-Grade Potato.....	" " " "	B. F. Ward, Hainesburg.	7844
6959	Collins Brand.....	J. S. Collins & Son, Moorestown, N. J.	H. I. Budd, Mount Holly.	6959
7823	Plant-Food No. 4.....	A. S. Core Fertilizer Works, Buffalo, N. Y.	B. F. Ward, Hainesburg.	7823
6889	Potato, Hop and Tobacco Phosphate.....	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.	H. I. Budd, Mount Holly.	6889
6840	Ammoniated Superphosphate.....	" " " "	" " "	6840

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	Nitrogen.										Phosphoric Acid.						Potash.		Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
	From Nitrates.			From Ammonia Salts.			From Organic Matter.				Total Found.		Total Guaranteed.		Available.		Found.	Guaranteed.			
6835	Glendennin's Farmers' Favorite.....	.....	1.19	1.19	0.82	1.10	4.40	5.33	10.83	9.00	5.50	8.00	1.11	1.00	1.89	\$12.51	6835				
8036	" National Stand. Ammon. Phos.....	.....	1.84	1.34	1.23	4.98	4.41	2.51	11.90	13.00	9.39	10.00	1.49	1.50	1.94	16.42	8036				
6837	" Special Potato and Truck.....	0.64	1.88	2.52	2.46	8.51	3.82	1.09	8.42	.....	7.33	6.00	6.00	6.00	6.98	20.89	6837				
7426	Coe's Excelsior Guano.....	0.69	2.89	3.58	3.28	8.00	0.54	2.82	11.36	10.00	8.54	9.00	4.00	3.40	0.44	24.62	7426				
6992	" " Red Brand.....		1.02	2.55	3.57	3.28	7.16	0.37	2.53	10.06	10.00	7.33	9.00	6.58	6.00	0.70	25.99	6992			
7085	" Alkaline Bone.....	.....	1.59	1.59	1.23	7.14	2.13	4.41	13.68	11.00	9.27	9.00	1.98	1.85	0.41	18.33	7085				
7401	" Dissolved Bone Phosphate.....	.....	1.29	1.29	1.23	7.72	1.49	3.69	12.90	.....	9.21	10.00	2.47	2.25	0.89	17.64	7401				
6994	" High-Grade Fish Guano and Potash.....	.....	3.16	3.16	3.28	8.08	2.98	2.61	8.67	.....	6.06	6.00	3.01	2.16	6.53	19.27	6994				
6803	" Peach Tree Fertilizer.....	0.26	1.57	1.82	1.23	6.80	1.46	3.60	11.86	.....	8.26	8.00	5.27	5.00	0.50	20.88	6803				
6804	" Celebrated Special Potato.....	0.38	1.59	1.95	1.64	7.10	1.46	3.70	12.20	.....	8.56	9.00	4.04	3.50	0.44	20.41	6804				
6805	" Excelsior Potato.....	0.87	1.98	2.85	2.46	8.16	0.37	1.26	9.79	.....	8.53	8.00	7.71	8.00	0.64	25.67	6805				
7344	" High-Grade Potato.....	0.49	1.86	2.35	2.46	7.26	1.26	3.15	11.63	9.00	8.50	8.00	5.26	6.00	0.37	22.51	7344				
6959	Collins Brand.....	1.56	2.22	3.78	2.46	4.60	4.10	3.80	12.50	11.00	8.70	.....	5.46	6.00	0.71	26.43	6959				
7823	Coe's Plant-Food, No. 4.....	.....	1.56	1.56	1.64	4.80	1.47	4.04	10.31	8.00	6.27	7.00	7.10	7.00	7.01	19.28	7823				
6839	Crocker's Potato, Hop and Tobacco.....	.....	2.81	2.31	2.05	7.55	2.72	2.18	12.30	11.00	10.27	10.00	3.75	3.25	3.85	21.96	6839				
6840	" Ammoniated Superphosphate.....	.....	1.16	1.16	0.82	5.18	3.94	2.61	11.63	.....	9.02	8.00	1.36	1.00	1.88	15.43	6840				

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY	Station Number.
6979	Special Potato Manure.....	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.	D. C. Crane, Westfield.	6979
7427	Ammoniated Wheat and Corn.....	" " " " " "	W. R. Ward, Lyons Farms.	7427
7431	Vegetabl Bone Superphosphate.....	" " " " " "	" " " "	7431
7473	Pure Bone Phosphate.....	I. S. Curtis, Frenchtown, N. J.	R. Budd, Frenchtown.	7473
7026	Long Island Brand A.....	L. B. Darling Fertilizer Co., Pawtucket, R. I.	D. N. Warbasse, Hantsburg.	7026
7478	Anchor Brand.....	" " " " " "	D. C. Lewis, Cranbury.	7478
7477	G Brand.....	" " " " " "	" " " "	7477
7091	Special Potato Manure.....	J. J. Dilatash, Allentown, N. J.	J. M. Dalrymple, Hopewell.	7091
7067	Sure-Shot Superphosphate.....	H. W. Doughten, Moorestown, N. J.	H. I. Budd, Mount Holly.	7067
7068	Dried and Ground Fish Guano.....	" " " " " "	" " " "	7068
7069	Potato Manure	" " " " " "	" " " "	7069
7442	Pioneer Raw Bone Superphosphate.....	J. G. Downward & Co., Coatesville, Pa.	T. F. Baker, Bridgeton.	7442
7443	Special Corn Manure	" " " " " "	" " " "	7443
7010	Cartaret Potato Manure.....	Eastern Farm Supply Association, Montclair.	D. C. Crane, Westfield.	7010
7011	" Long Island Special.....	" " " " " "	" " " "	7011
7276	Potato Fertilizer.....	Runyon Field, Bound Brook, N. J.	D. N. Warbasse, Hantsburg.	7276

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	Nitrogen.						Phosphoric Acid.						Potash.		Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.	
	From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available.		Found.	Guaranteed.					
											Found.	Guaranteed.							
																			Found.	Guaranteed.
6879 Crocker's Special Potato.....			3.69	3.69	3.69	6.70	1.14	1.59	9.43	9.00	7.84	8.00	5.56	5.40	5.72	\$24.50	\$40.00	6879	
7427 " Ammoniated Wheat and Corn			2.27	2.27	2.05	9.81	1.17	2.16	13.14	11.00	10.98	10.00	1.82	1.62	1.82	20.94	36.00	7427	
7481 " Vegetable Bone Superphosphate			5.10	5.10	4.92	5.84	0.64	0.70	7.18	7.00	6.48	6.00	5.86	5.94	6.04	26.95	42.00	7481	
7473 Curtis' Pure Bone Phosphate.....		0.78	2.29	3.07	2.05	1.86	4.94	8.90	14.60	.....	5.70	6.00	2.37	3.00	2.29	20.71	30.00	7473	
7026 Darling's Long Island Brand A.....			3.50	3.50	3.00	2.60	4.72	5.21	12.53	.....	7.32	6.00	7.70	7.00	8.08	26.94	37.00	7026	
7478 " Anchor Brand.....			2.15	2.15	1.64	4.24	4.58	4.78	13.60	7.00	8.82	.....	2.49	2.00	6.51	19.87	25.00	7478	
7477 " G Brand.....			2.49	2.49	2.05	5.25	4.52	5.29	15.09	7.00	9.80	6.00	4.14	4.00	4.88	23.60	29.00	7477	
7091 Dilatash's Special Potato.....	0.47	.....	1.27	1.74	1.04	5.54	0.66	6.17	12.37	7.00	6.20	5.00	11.13	10.00	10.81	24.14	28.00	7091	
7067 Doughten's Sure-Shot Superphosphate			2.69	2.69	2.87	10.96	1.09	1.57	13.62	14.00	12.05	11.00	4.21	5.50	0.74	25.53	30.00	7067	
7068 " Dried and Ground Fish.....			0.20	3.49	3.69	4.10	8.50	2.64	2.99	9.13	6.00	6.14	.....	4.80	3.89	22.67	30.00	7068	
7069 " Potato Manure.....			3.06	3.06	1.23	10.64	2.19	1.82	14.15	9.00	12.83	.....	3.48	7.00	0.45	26.68	31.00	7069	
7442 Downward's Pioneer Raw Bone.....	0.58	.....	1.62	2.15	2.46	6.48	1.64	1.20	9.32	.....	8.12	8.00	5.21	5.00	8.76	26.07	31.00	7442	
7443 " Special Corn.....			0.43	1.56	1.99	1.64	7.14	1.97	2.57	11.68		9.11	9.00	3.58	3.50	6.78	19.93	27.00	7443
7010 Cartaret Potato Manure		0.56	0.56	2.46	3.58	2.87	3.74	4.45	1.49	9.68	8.00	8.19	7.00	7.21	7.00	5.74	26.18	32.00	7010
7011 " Long Island Special.....		0.82	0.21	8.28	3.81	3.28	5.82	3.06	1.00	9.88	11.00	8.88	8.50	8.17	8.00	2.78	28.64	35.00	7011
7275 Field's Potato Fertilizer.....	1.85	.....	2.04	3.39	3.28	5.49	2.66	1.22	9.37	9.00	8.15	7.00	7.83	7.50	5.08	25.99	30.00	7275	

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number
6985	Fish and Potash.....	J. C. Fifield & Sons Bakersville, N. J.	H. I. Budd, Mount Holly.	6985
6982	Special Sweet Potato Manure.....	" " " " " "	" " " " " "	6982
6906	Potato and Cabbage Manure.....	" " " " " "	C. Kraus, Egg Harbor City.	6906
7808	Our Pride Fish Guano.....	Garrison & Minch, Bridgeton, N. J.	J. H. Richardson, Rio Grande.	7808
7444	Truckers' Pride.....	" " " " " "	T. F. Baker, Bridgeton.	7444
7445	Bay Side Fertilizer.....	" " " " " "	" " " " " "	7445
7446	Farmers' Pride for Hill and Drill.....	" " " " " "	" " " " " "	7446
7448	Murphy Brand.....	" " " " " "	" " " " " "	7448
7449	Pride of Cumberland.....	" " " " " "	" " " " " "	7449
7450	Double XX Pride.....	" " " " " "	" " " " " "	7450
6856	Oak Island Fertilizer.....	Theodore Glaser, Elizabeth, N. J.	C. Kraus, Egg Harbor City.	6856
7228	General Vegetable, Vine and Tobacco.....	Great Eastern Fertilizer Co., Rutland, Vt.	J. H. Deulse, Freehold.	7228
7422	Garden Special.....	" " " " " "	C. C. Hulsart, Matawan.	7422
7204	Keystone Bone Phosphate.....	S. M. Hess & Bro., Reading, Pa.	A. Ditta, Copper Hill.	7204
7208	Potato and Truck Manure.....	" " " " " "	" " " " " "	7208
7471	Ammoniated Bone Superphosphate.....	" " " " " "	P. Barclay, Monmouth Junction.	7471

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.		Nitrogen.				Phosphoric Acid.							Potash.		Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
		From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Available.				Found.	Guaranteed.						
							Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.			Total Guaranteed.					
														Found.					Guaranteed.
6985	Fifield's Fish and Potash.....	0.89	2.50	2.88	3.28	3.28	1.86	2.07	1.97	5.90	4.00	3.93	2.99	\$30.00	6985			
6992	" Special Sweet Potato.....	.....	.....	1.90	2.05	2.05	3.54	1.41	1.76	6.71	.....	4.95	10.44	35.00	6992			
6996	" Potato and Cabbage.....	.....	.....	2.36	2.56	2.46	5.66	1.61	2.50	9.77	.....	7.27	7.00	35.00	6996			
7308	G. & M.'s Our Pride Fish Guano.....	0.82	1.58	2.40	4.10	4.10	5.28	2.23	2.58	10.09	8.00	7.51	7.39	35.00	7308			
7444	" Truckers' Pride	1.50	2.11	3.61	4.10	4.05	6.45	1.17	2.28	9.90	8.00	7.62	7.54	35.00	7444			
7445	" Bay Side Fertilizer.....	.....	.....	1.04	1.04	2.05	7.99	1.56	2.72	12.27	.....	9.55	1.80	25.00	7445			
7446	" Farmers' Pride Hill and Drill.....	1.01	1.30	2.31	1.64	1.64	6.87	2.80	4.08	13.25	9.00	9.17	2.38	25.00	7446			
7448	" Murphy Brand.	1.27	0.78	2.00	2.87	2.87	6.88	1.07	2.05	9.50	8.00	7.45	8.02	30.00	7448			
7449	" Pride of Cumberland.....	0.48	1.01	1.49	2.05	2.05	6.14	3.01	3.09	12.24	.....	9.15	3.36	25.00	7449			
7450	" Double XX Pride.....	.....	0.75	0.75	0.82	0.82	7.61	2.05	2.64	12.30	.....	9.06	1.33	19.00	7450			
6956	Glaser's Oak Island Fertilizer.....	.....	1.10	2.06	3.16	2.46	0.50	2.48	0.22	3.20	6.00	2.98	2.86	28.00	6956			
7228	Great Eastern General Vegetable, Vine, etc.....	.....	.....	2.16	2.16	2.05	0.81	7.76	2.90	11.47	9.00	8.57	3.50	30.00	7228			
7422	" " Garden Special.....	0.41	0.47	2.70	3.58	3.28	4.31	2.62	2.19	9.06	.....	6.93	7.96	37.00	7422			
7204	Hess' Keystone Bone Phosphate.....	0.29	.....	1.54	1.83	0.82	7.44	2.11	1.57	11.12	11.00	9.55	2.28	25.00	7204			
7208	" Potato and Truck Manure.	0.49	0.40	1.82	2.71	2.46	2.82	0.95	1.95	10.72	.....	8.77	6.00	33.00	7208			
7471	" Ammoniated Bone Superphosphate.....	0.80	0.57	1.50	2.07	1.64	8.27	1.57	1.62	11.46	.....	9.84	2.78	25.00	7471			

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
7205	Pure Bone Phosphate.....	Ira Hill, Copper Hill, N. J.	A. Dilts Copper Hill.	7205
7206	Pure Potato Phosphate.....	" " " "	" " "	7206
7147	Potato and Tomato Grower.....	Hires & Co, Quinton, N. J.	W. Pettit, Salem.	7147
7148	Standard Bone Phosphate.....	" " " "	" " "	7148
7146	Corn, Oats and Wheat Phosphate.....	" " " "	" " "	7146
7145	Special High-Grade Potato Manure.....	" " " "	" " "	7145
7452	Complete Phosphate.....	B. F. Hires, Bridgeton, N. J.	T. F. Baker, Bridgeton.	7452
7160	Special Potato and Tomato.....	W. B. Hitchner, Woodstown, N. J.	W. Pettit, Salem.	7160
7161	Special Corn, Oats and Wheat.....	" " " "	" " "	7161
7846	Corn Manure.....	Hopler & Lomasson, Belvidere, N. J.	B. F. Ward, Hainesburg.	7846
7847	Potato Fertilizer.....	" " " "	" " "	7847
7848	Corn Phosphate.....	" " " "	" " "	7848
7849	Potato Phosphate.....	" " " "	" " "	7849
7813	Harvest Queen Phosphate.....	The Keystone Chemical Mfg. Co., Camden, N. J.	J. H. Richardson, Rio Grande.	7813
7812	South Jersey Economizer.....	" " " "	" " "	7812
7208	Special Potato Manure.....	" " " "	A. Dilts, Copper Hill.	7208
7207	Pectorial Corn Manure.....	" " " "	" " "	7207

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	Nitrogen.						Phosphoric Acid.				Potash.		Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
	From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.		Soluble in Water.	Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available.				
											Found.	Guaranteed.				
7206	.....	.....	2.82	2.32	2.05	3.04	5.19	2.97	11.20	10.50	8.23	.....	2.99	2.50	7.06	7205
7206	.....	.....	2.85	2.85	2.46	3.38	6.00	2.75	12.13	.....	9.38	10.00	8.84	9.00	11.15	7206
7147	.....	.....	2.85	2.85	2.46	4.74	3.09	2.30	10.13	10.00	7.83	8.00	4.57	5.00	2.41	7147
7148	.....	.....	1.76	1.76	1.64	5.90	2.30	2.31	10.51	9.50	8.20	8.00	2.89	3.00	1.85	7148
7146	.....	.....	0.98	0.93	0.82	4.30	3.45	2.88	10.58	9.00	7.75	8.00	2.03	2.00	5.42	7146
7145	.....	.....	2.61	2.61	2.46	6.86	2.13	1.81	10.80	10.00	8.99	8.00	7.36	8.00	2.43	7145
7452	0.86	.....	1.86	2.24	2.05	5.70	3.07	5.16	13.93	.....	8.77	9.00	3.74	3.00	3.74	7452
7160	.....	.....	2.57	2.50	2.46	7.82	0.84	2.42	11.08	.....	8.66	8.00	4.60	5.00	4.97	7160
7161	.....	.....	0.85	0.85	0.82	2.94	4.85	2.72	10.01	.....	7.29	8.00	1.94	2.00	4.88	7161
7846	0.24	.....	0.26	0.50	2.00	9.08	0.99	0.47	10.54	8.00	10.07	.....	6.24	4.00	11.84	7846
7847	0.38	.....	0.21	0.59	3.00	7.40	1.80	0.94	10.14	10.00	9.20	.....	5.77	7.00	10.48	7847
7848	.....	.....	0.21	0.21	2.00	5.45	1.75	0.47	7.67	6.00	7.20	.....	6.02	3.00	13.41	7848
7849	0.84	0.51	0.24	1.09	3.00	5.22	1.93	0.91	8.06	9.00	7.15	.....	6.04	6.00	8.18	7849
7818	.....	.....	1.09	1.09	0.82	3.62	6.67	3.41	13.70	.....	10.29	10.00	1.38	1.00	1.66	7818
7812	1.18	.....	1.12	2.30	1.85	5.96	3.84	2.44	12.24	.....	9.80	8.50	3.13	2.50	8.41	7812
7208	.....	.....	1.74	1.74	1.64	5.53	3.85	3.13	12.51	.....	9.38	8.00	4.62	5.00	5.00	7208
7207	.....	.....	0.96	0.95	0.82	6.97	5.09	2.62	14.68	.....	12.06	10.00	0.96	1.00	1.20	7207

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
7256	Wheat and Grass Grower.....	The Keystone Chemical Mfg. Co., Camden, N. J.	J. M. White, New Brunswick.	7256
7018	Honest Potato Manure.....	Samuel Lederer & Son, New Brunswick, N. J.	Station.	7018
7332	Lawn Fertilizer.....	Lister's Agricultural Chemical Works, Newark, N. J.	W. R. Ward, Lyons Farms.	7332
7359	Potato Manure.....	" "	" "	7359
6340	Potato Fertilizer, No. 2.....	" "	H. I. Budd, Mount Holly.	6340
6361	Ammoniated Dissolved Bone Phosphate.....	" "	" "	6361
7210	Success Fertilizer.....	" "	A. Dilla, Copper Hill.	7210
7404	Special 10 per cent. Potato Fertilizer.....	" "	J. M. Dalrymple, Hopewell.	7404
7163	Harvest Queen Phosphate.....	" "	W. Pettit, Salem.	7163
7162	Special Potato Fertilizer.....	" "	" "	7162
7028	U. S. Superphosphate.....	" "	D. N. Warbasse, Hantsburg.	7028
7027	Celebrated Onion Fertilizer.....	" "	" "	7027
6373	Standard Pure Bone Superphosphate.....	" "	D. C. Crane, Westfield.	6373
7337	Corn Fertilizer, No. 2.....	" "	B. F. Ward, Hainesburg.	7337
7352	Special 3-10-5.....	" "	J. Brakeley, Freehold.	7352
7231	Cecrops Brand.....	Frederick Ludlam, New York City.	J. H. Denise, Freehold.	7231

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	Nitrogen.					Phosphoric Acid.					Potash.		Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.			
	From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available.							
											Found.	Guaranteed.						
																Found.	Guaranteed.	
7236			1.08	1.03	0.82	6.69	4.89	2.87	14.45	.....	11.58	10.00	1.05	1.00	7236			
7018	0.20	0.61	1.24	2.05	3.28	0.20	2.92	9.97	12.69	10.00	3.12	.....	6.70	10.00	0.43	19.74	25,000	7018
7862	0.47	1.27	0.50	2.24	1.64	5.15	2.68	0.98	8.76	8.00	7.83	7.00	3.79	3.50	0.58	19.18	26,500	7862
7859		1.95	2.15	4.10	3.69	6.85	0.85	1.42	9.12	8.50	7.70	7.50	7.39	7.00	0.27	27.57	37,000	7859
6940		0.31	1.66	1.97	1.80	8.60	2.54	1.76	12.90	12.00	11.14	9.25	4.25	4.00	4.19	22.36	30,000	6940
6961		0.25	1.85	2.10	1.80	7.78	0.97	3.14	11.89	11.00	8.75	9.00	1.87	1.50	2.04	18.50	29,000	6961
7210			1.58	1.53	1.23	8.96	2.01	2.70	13.67	11.50	10.97	9.50	1.44	2.00	0.81	18.76	25,000	7210
7404		1.89	1.09	2.98	2.46	9.48	1.08	0.55	11.11	.....	10.56	10.00	8.83	10.00	0.76	29.29	30,000	7404
7168		0.21	1.87	1.58	1.23	9.00	0.59	2.99	12.58	11.50	9.59	9.50	2.30	2.00	0.46	18.46	26,000	7168
7162		0.30	1.58	1.83	1.64	7.44	1.80	2.29	11.53	9.00	9.24	8.00	4.48	3.00	4.47	20.29	26,000	7162
7028			1.66	1.66	1.31	6.28	2.03	2.32	10.63	8.00	8.31	7.00	2.38	2.00	0.84	16.99	26,000	7028
7027		1.98	2.17	4.15	3.69	7.05	0.89	1.48	9.37	8.50	7.94	7.50	7.35	7.00	4.47	27.95	40,000	7027
6973		0.29	2.06	2.34	2.34	8.66	1.63	2.74	13.03	12.00	10.20	10.00	1.91	1.50	1.90	20.75	31,000	6973
7387		0.21	1.76	1.97	1.80	8.99	1.82	1.59	11.90	12.00	10.31	9.25	4.47	4.00	2.78	21.64	32,000	7387
7382		0.83	2.66	3.04	2.46	9.51	1.03	1.33	11.87	.....	10.54	10.00	5.64	5.00	1.92	26.10	27,050	7382
7231		1.62	.....	1.62	3.24	3.28	7.88	1.50	1.48	10.36	.....	8.88	7.00	7.02	6.57	25.59	36,000	7231
Ludlum's Cereals Brand.....																		

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
6897	Fruit and Vine Manure.....	The Mapes F. & P. Guano Co., New York City.	C. Kraus, Egg Harbor City.	6897
6890	Complete Manure for Heavy Soils.....	" " " " " " " "	" " " " " " " "	6890
6896	Complete Manure for General Use.....	" " " " " " " "	" " " " " " " "	6896
7071	Economical Manure.....	" " " " " " " "	H. I. Budd, Mount Holly.	7071
7112	Potato Manure.....	" " " " " " " "	I. W. Nicholson, Camden.	7112
7115	Complete Manure, "A" Brand.....	" " " " " " " "	" " " " " " " "	7115
7871	Cauliflower and Cabbage Manure.....	" " " " " " " "	W. R. Ward, Lyons Farms.	7871
7876	Lawn Top-Dressing.....	" " " " " " " "	" " " " " " " "	7876
7412	Corn Manure.....	" " " " " " " "	J. M. Dalrymple, Hopewell.	7412
7411	Ammoniated Dissolved Bone with Potash.....	" " " " " " " "	" " " " " " " "	7411
7164	Cereal Brand.....	" " " " " " " "	W. Pettit, Salem.	7164
7845	Complete Manure for Light Soils.....	" " " " " " " "	B. F. Ward, Hainesburg.	7845
7866	Buffalo Fertilizer.....	Millson Rend. & Fert. Co., East Buffalo, N. Y.	W. R. Ward, Lyons Farms.	7866
7867	Potato, Hop and Tobacco Phosphate.....	" " " " " " " "	" " " " " " " "	7867
7454	Complete Phosphate.....	Minch & Harris, Bridgeton, N. J.	T. F. Baker, Bridgeton.	7454
7488	Potato Fertilizer.....	Mitchell Manufacturing Co., Tremley, N. J.	W. R. Ward, Lyons Farms.	7488
7469	Special Potato Fertilizer.....	" " " " " " " "	C. Probasco, Manalapan.	7469

Complete Fertilizers.
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	Nitrogen.				Phosphoric Acid.				Potash.		Value of 2,000 Lbs. at Stations' Prices.	Selling Price of 2,000 Lbs. at Consumers' Depot.	Station Number.				
	From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Available.		Found.	Guaranteed.								
						Found.	Guaranteed.										
6897	0.40	0.86	1.42	2.18	1.64	5.08	2.81	0.88	8.77	7.00	7.89	5.00	11.17	10.00	0.52	\$26.27	6897
"	1.27	0.59	3.30	5.16	4.92	4.54	4.81	1.90	11.35	10.00	9.45	8.00	3.67	3.00	0.59	29.18	6890
"	1.18	0.56	1.94	3.68	3.28	5.55	4.07	1.33	10.95	10.00	9.62	8.00	4.61	4.00	8.40	25.57	6895
7071	0.64	.....	1.81	2.45	2.46	3.91	4.02	2.17	10.10	8.00	7.93	6.00	8.99	8.00	12.01	24.48	7071
"	1.70	0.61	1.68	3.99	3.69	4.76	4.66	1.37	10.79	8.00	9.42	8.00	7.27	6.00	0.54	29.24	7112
"	0.60	.....	2.28	2.88	2.46	7.20	3.70	1.80	12.70	12.00	10.90	10.00	3.14	2.50	5.27	23.54	7115
7371	0.93	0.48	2.93	4.34	4.10	3.97	2.89	1.00	7.86	6.00	6.86	6.00	7.32	6.00	0.60	26.69	7371
"	1.91	.....	0.63	2.59	2.46	1.69	2.54	1.01	5.24	4.00	4.23	.....	3.41	2.50	3.19	15.18	7375
7412	0.34	0.23	1.68	2.25	2.46	6.74	3.43	1.33	11.50	10.00	10.17	8.00	7.26	6.00	7.06	24.55	7412
"	.....	.....	1.50	1.50	1.23	6.55	6.27	1.20	14.02	12.00	12.82	10.00	1.85	1.50	4.66	20.46	7411
7164	0.91	.....	1.11	2.02	1.64	6.35	1.61	0.67	8.63	8.00	7.96	6.00	3.12	3.00	6.71	17.41	7164
"	1.25	0.61	2.65	4.51	4.92	4.20	3.73	2.19	10.12	8.00	7.93	6.00	7.19	6.00	7.79	28.70	7345
7366	.....	.....	2.21	2.21	2.46	7.26	1.49	2.38	11.13	10.00	8.75	8.00	1.17	1.00	0.55	17.86	7366
"	.....	.....	2.39	2.39	2.46	7.26	1.48	2.03	10.77	9.00	8.74	8.00	4.13	6.00	3.38	20.84	7367
7454	1.00	.....	1.20	2.20	2.05	3.20	2.88	5.19	11.27	.....	6.08	9.00	3.39	2.50	3.57	17.88	7454
7433	1.47	.....	2.44	3.91	2.87	7.12	2.61	1.21	10.94	9.00	9.73	8.00	5.84	6.00	0.35	27.77	7433
"	1.96	.....	2.41	4.37	4.10	4.11	2.28	1.36	8.25	9.00	6.39	8.00	9.00	8.00	2.53	28.42	7469

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
7456	Special Manure.....	Mixner & Mickel, Bridgeton, N. J.	T. F. Baker, Bridgeton.	7455
7457	High-Grade Manure.....	" " " "	" " "	7457
7458	Complete Manure.....	" " " "	" " "	7458
6810	Chittenden's Potato Phosphate.....	National Fertilizer Co., Bridgeport, Conn.	J. H. Denhae, Freehold.	6810
6811	" Market Garden.....	" " " "	" " "	6811
6976	" Complete for Roots.....	" " " "	D. C. Crane, Westfield.	6976
7890	" Ammoniated Bone.....	" " " "	J. J. Mitchell, Troy Hills.	7890
6974	" Fish and Potash.....	" " " "	D. C. Crane, Westfield.	6974
7087	Special Grain and Grass Fertilizer.....	Albert Nelson, Allentown, N. J.	J. M. Dalrymple, Hopewell.	7087
7086	Complete Manure for Grain and Grass.....	" " " "	" " "	7086
7084	" Corn and Potato Manure.....	" " " "	" " "	7084
7085	Special Potato Manure.....	" " " "	" " "	7085
7290	" Oats Manure.....	" " " "	" " "	7290
7291	" Truck Manure.....	" " " "	" " "	7291
7872	Schenck's Potato Manure, No. 1.....	Newark Agricultural Co., Newark, N. J.	W. R. Ward, Lyons Farms.	7872
7874	" " " No. 2.....	" " " "	D. N. Warbasse, Hartsburg.	7874
7898	" Wheat and Corn.....	" " " "	J. J. Mitchell, Troy Hills.	7898

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	Nitrogen.				Phosphoric Acid.						Potash.		Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
	From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available.					
											Found.	Guaranteed.				
7455	.....	.....	.....	1.03	1.03	1.03	4.32	6.96	13.52	10.00	11.27	.....	2.47	2.50	8.04	7455
"	0.20	0.28	1.81	2.29	2.40	5.56	3.61	2.11	11.22	9.00	9.11	.....	7.67	8.00	7.99	7457
7458	.....	.....	.....	1.80	1.80	2.05	0.89	3.19	11.61	9.00	9.08	.....	2.65	2.50	3.11	7458
6810	.....	.....	.....	2.16	2.05	0.44	4.60	8.72	8.76	8.00	5.04	6.00	8.56	8.00	8.54	6810
"	.....	.....	.....	2.89	2.69	2.46	0.77	5.49	8.72	9.98	6.26	7.00	5.54	6.00	5.38	6811
"	0.59	0.51	2.43	3.53	3.28	4.16	4.75	1.27	10.18	10.00	8.91	8.00	5.86	6.00	5.99	6876
7390	0.32	.....	1.49	1.81	1.64	0.78	2.43	8.85	11.87	9.00	8.02	7.00	2.79	2.00	3.09	7390
"	.....	.....	.....	2.41	2.41	2.87	4.20	3.40	8.75	11.35	7.60	6.00	3.18	4.00	8.24	6874
7087	0.63	.....	0.92	1.55	0.83	9.70	0.83	1.56	12.09	9.00	10.53	8.00	3.53	2.00	1.72	7087
"	1.41	...	1.71	3.12	1.64	6.24	1.67	2.06	9.97	9.00	7.91	8.00	8.30	2.00	5.36	7086
7084	1.56	.....	0.98	2.49	0.89	7.52	1.17	1.00	9.69	9.00	8.69	8.00	9.93	6.00	8.98	7084
7085	1.77	.....	1.56	3.33	1.23	5.84	1.80	1.22	8.66	9.00	5.64	8.00	17.37	10.00	14.04	7085
"	.....	0.28	1.80	2.08	0.82	7.53	1.59	2.00	11.17	.....	9.17	7.00	2.72	1.00	2.78	7290
7290	.....	.....	.....	1.15	1.82	0.82	7.26	1.63	1.89	10.32	8.93	8.00	8.46	8.00	8.94	7291
"	0.87	.....	0.74	3.08	3.28	4.21	2.83	8.41	10.00	9.50	6.59	8.00	6.81	7.00	6.59	7372
Schenck's Potato, No. 1.....	2.84	.....	0.99	2.09	1.85	6.20	1.16	2.50	9.86	8.50	7.36	7.00	4.05	4.00	8.76	7374
"	1.10	.....	0.99	2.09	1.85	6.20	1.16	2.50	9.86	8.50	7.36	7.00	4.05	4.00	8.76	7374
"	.....	0.28	1.12	1.35	1.23	4.80	1.09	2.79	8.68	8.75	5.89	7.00	2.27	2.00	2.25	7368
"	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7368

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
7158	Adduluted Bone Phosphate.....	New Jersey Farmers' Exchange, Elmer, N. J.	W. Pettit, Salem.	7158
7151	Special Corn Manure.....	" " " " " "	" " " " " "	7151
7830	" Potato Phosphate.....	" " " " " "	B. F. Ward, Hainesburg,	7830
7829	" Corn and Truck Phosphate.....	" " " " " "	" " " " " "	7829
6877	Zelloo Grain and Grass Maker.....	New York Fert. & Chem Co., New York City.	D. C. Crane, Westfield.	6877
6878	" Special Potato Fertilizer.....	" " " " " "	" " " " " "	6878
6876	" Truck Garden Special.....	" " " " " "	" " " " " "	6876
7184	Stickler's Standard High-Grade Potato.....	Niagara Manufacturing Co., Buffalo, N. Y.	J. C. Griscom, Woodbury.	7184
6827	Menhaden Fish Guano.....	James E. Otis, Tuckerton, N. J.	H. I. Budd, Mount Holly.	6827
6871	Nobeque Guano.....	Pacific Guano Co., New York City.	D. C. Crane, Westfield.	6871
6870	A No. 1 Phosphate.....	" " " " " "	" " " " " "	6870
6869	Potato Phosphate.....	" " " " " "	" " " " " "	6869
7485	Universal Fertilizer.....	Packers' Union Fertilizer Co., New York City.	W. R. Ward, Lyons Farms,	7485
7108	Parker's High-Grade Special Potato.....	S. L. Pancoast, Mullies Hill, N. J.	J. C. Griscom, Woodbury.	7108
7189	Early Truckee.....	Palapaco Guano Co., Baltimore, Md.	W. Pettit, Salem.	7189
7140	Ammoniated Corn Fertilizer.....	" " " " " "	" " " " " "	7140
7141	Columbia Guano.....	" " " " " "	" " " " " "	7141

Complete Fertilizers Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.		Nitrogen.				Phosphoric Acid.						Potash.		Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.		
		From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.			Total Found.	Total Guaranteed.	Available.					Found.	Guaranteed.
							Soluble in Ammonium Citrate.	Insoluble.	Total Found.			Found.	Guaranteed.					
71553	Acidulated Bone Phosphate.....	.....	.....	.....	1.88	1.64	5.75	6.07	0.86	13.68	.....	11.82	9.00	3.09	2.00	3.40	\$21.00	7153
7151	Special Corn Manure.....	.....	.....	.....	0.98	0.82	4.52	6.06	3.99	14.57	.....	10.58	8.00	2.52	3.00	3.02	18.25	7151
7880	" Potato Phosphate.....	.....	.....	.....	2.39	2.39	2.05	0.61	5.62	9.26	.....	7.17	8.00	10.07	8.00	2.00	25.23	7880
7829	" Corn and Truck.....	1.18	.....	.....	0.99	2.12	1.64	0.74	7.28	10.31	.....	8.02	8.00	3.89	5.00	9.07	19.06	7829
6977	Zelloo Grain and Grass Maker.....	.....	.....	.....	1.69	1.69	1.23	7.94	1.32	8.61	11.00	9.26	10.00	1.95	1.00	2.10	18.11	6977
6978	" Special Potato.....	.....	.....	.....	3.49	3.49	3.28	6.52	1.60	1.71	9.83	9.00	8.12	8.00	7.40	7.00	26.04	6978
6976	" Truck Garden Special.....	.....	.....	.....	3.36	3.36	3.28	5.73	2.11	1.85	9.74	7.89	8.00	4.99	4.80	5.11	23.32	6976
7134	Sickler's Standard High-Grade Potato.....	.....	.....	.....	3.62	3.62	3.38	6.44	1.41	1.57	9.45	7.88	8.00	8.63	8.00	3.82	27.20	7134
6927	Otis' Menhaden Fish Guano.....	.....	0.36	3.58	3.94	3.28	5.30	1.39	2.69	9.38	7.00	6.69	.....	3.21	5.00	3.78	22.43	6927
6971	Pacific Nobesque Guano.....	.....	.....	.....	1.36	1.30	1.18	3.30	4.34	4.25	11.89	7.64	8.00	1.89	2.00	3.74	15.44	6971
6970	" A No. 1 Phosphate.....	.....	.....	.....	1.24	1.24	1.03	2.97	4.77	8.78	11.52	7.74	7.00	2.07	1.50	4.19	15.36	6970
6989	" Potato Phosphate.....	.....	0.21	1.25	1.46	1.23	2.56	3.61	3.96	10.15	7.00	6.17	6.00	5.04	5.00	1.99	17.05	6989
7485	Packers' Union Universal Fertilizer.....	.....	.....	.....	1.79	1.79	0.82	5.60	2.40	3.01	11.01	8.00	8.00	6.36	5.00	1.94	21.11	7485
7106	Parkers' High-Grade Special Potato.....	0.74	.....	.....	2.17	2.91	2.46	8.20	0.44	1.48	10.12	9.00	8.64	7.00	7.00	7.71	25.18	7106
7189	Patapasco Early Truckee.....	.....	1.63	2.36	3.98	4.10	5.76	1.79	1.84	9.39	.....	7.55	7.00	5.29	5.00	7.21	25.28	7189
7140	" Ammoniated Corn.....	.....	.....	.....	1.48	1.48	1.23	7.72	1.61	1.58	10.91	9.33	9.00	2.08	2.00	9.49	16.90	7140
7141	" Columbia Guano.....	.....	.....	.....	2.21	2.21	2.46	7.80	2.02	1.59	11.41	9.82	9.00	2.41	3.00	6.36	19.80	7141

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
7166	Potato and Tomato Superphosphate	Peterson & Smith, Woodstown, N. J.	W. Pettit, Salem.	7166
7166	Special Mixture for Corn	" " " "	" " " "	7166
7167	Potato Superphosphate	" " " "	" " " "	7167
7168	Wheat and Oats Superphosphate	" " " "	" " " "	7168
6870	Union High-Grade	Moro Phillips Chemical Co., Philadelphia, Pa.	C. Kraus, Egg Harbor City.	6870
6871	" Fish and Potash	" " " "	" " " "	6871
6999	King Crab Compound	" " " "	J. C. Griscom, Woodbury.	6999
6997	No. 1	" " " "	" " " "	6997
6998	No. 2	" " " "	" " " "	6998
7000	Sweet Potato Manure	" " " "	" " " "	7000
7015	Special Fertilizer	" " " "	" " " "	7015
7261	New Jersey Potato Manure	" " " "	J. M. White, New Brunswick.	7261
7263	Standard	" " " "	" " " "	7263
7806	Farmers' Phosphate	" " " "	J. H. Richardson, Rio Grande.	7806
7807	" Potato Mixture	" " " "	" " " "	7807
7017	Potato Manure	G. H. Poinsett.	J. C. Griscom, Woodbury.	7017

EXPERIMENT STATION REPORT.

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Complete Fertilizers Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.		Nitrogen.						Phosphoric Acid.						Potash.		Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.								
		From Ammonia Salts.			From Organic Matter.			Total Found.			Total Guaranteed.			Soluble in Water.						Insoluble.		Total Found.		Total Guaranteed.		Available.	
		Found.	Guaranteed.	Round.	Found.	Guaranteed.	Round.	Found.	Guaranteed.	Round.	Found.	Guaranteed.	Round.	Found.	Guaranteed.					Round.	Found.	Guaranteed.	Round.	Found.	Guaranteed.	Round.	
7166	P. & S.'s Potato and Tomato.....	0.59	0.22	1.78	2.59	2.46	5.86	1.40	2.80	9.56	10.00	7.26	8.00	5.26	5.00	\$20.87	\$27.00	7166									
7166	" Special Corn.....	0.23	2.08	2.31	2.46	6.48	1.53	2.13	10.14	8.01	8.00	8.01	8.00	4.02	3.00	19.69	25.00	7166									
7167	" Potato Superphosphate.....	0.24	1.34	1.58	1.64	5.48	1.48	1.46	8.37	6.91	6.00	6.91	6.00	9.05	10.00	20.80	27.00	7167									
7168	" Wheat and Oats Superphosphate.....	.....	1.25	1.25	0.82	6.18	1.31	1.39	8.88	.....	.....	7.49	8.00	2.47	2.00	14.52	18.00	7168									
6870	Phillips' Union High-Grade.....	0.40	.....	2.48	2.88	3.28	6.81	2.17	2.08	10.56	.....	8.48	7.00	6.47	7.00	24.00	35.00	6870									
6871	" " Fish and Potash.....	0.83	2.01	2.34	2.46	3.75	1.86	1.99	7.60	.....	.....	5.61	4.50	4.88	4.00	17.99	29.00	6871									
6999	" King Crab Compound.....	1.84	2.49	4.33	4.10	6.62	1.08	1.04	8.73	10.00	7.65	8.00	6.12	5.00	6.97	26.84	35.00	6999									
6997	" No. 1.....	.....	3.18	3.18	2.46	5.74	2.06	1.87	9.67	7.80	6.00	7.80	6.00	5.10	5.00	32.82	27.00	6997									
6998	" No. 2.....	2.22	1.85	3.57	2.87	8.60	1.77	1.08	11.45	.....	.....	10.37	9.00	6.14	5.50	27.81	31.00	6998									
7000	" Sweet Potato Manure.....	.....	1.87	1.87	1.64	5.71	1.61	1.92	9.24	7.32	6.00	7.32	6.00	9.69	9.00	22.78	31.00	7000									
7015	" Special Fertilizer.....	.....	1.79	1.79	1.85	8.07	1.81	1.45	11.33	9.88	9.00	9.88	9.00	5.56	4.75	21.46	30.00	7015									
7281	" New Jersey Potato.....	.....	2.17	2.17	1.64	4.99	1.92	1.99	8.50	7.00	6.51	6.51	6.00	9.46	9.00	23.55	28.00	7281									
7286	" Standard.....	.....	1.35	1.35	1.50	7.20	2.21	1.64	11.05	11.00	9.41	9.41	9.00	4.57	2.50	18.90	25.00	7286									
7806	" Farmers' Phosphate.....	0.24	1.49	1.73	0.82	6.50	1.82	1.65	9.97	8.00	8.32	7.00	7.00	2.60	1.00	17.04	26.00	7806									
7807	" " Potato Mixture.....	.....	1.77	1.27	0.82	6.08	1.68	1.28	8.94	7.66	7.00	7.66	7.00	4.38	5.00	16.43	29.00	7807									
7017	Polnsett's Potato Manure.....	.....	2.63	2.63	2.46	6.80	1.74	3.10	11.64	9.00	8.54	8.54	7.00	7.48	7.00	24.72	28.00	7017									

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
6887	Surprise Fertilizer.....	Preston Fertilizer Co., Greenpoint, L. I.	C. Kraus, Egg Harbor City.	6887
7074	Tankage and Potash.....	" " " "	H. I. Budd, Mount Holly.	7074
7186	XXV Fertilizer.....	" " " "	T. F. Baker, Bridgeton.	7186
7186	Sweet Potato Fertilizer.....	" " " "	" " " "	7186
6812	Potato Brand.....	" " " "	J. H. Denise, Freehold.	6812
7282	" Special.....	" " " "	" " " "	7282
7896	Ammoniated Bone Phosphate.....	" " " "	J. J. Mitchell, Troy Hills.	7896
7080	Potato, Hop and Onion.....	" " " "	D. N. Warbasse, Hantsburg.	7080
7276	Fruit and Vine.....	" " " "	" " " "	7276
7486	Lawn Dressing.....	" " " "	W. R. Ward, Lyons Farms.	7486
7340	Potato Manure.....	The Quinnipiac Co., New York City.	B. F. Ward, Hainesburg.	7340
6891	Texas Manure.....	Ranocas Chemical Works, Philadelphia, Pa.	C. Kraus, Egg Harbor City.	6891
7217	Blood and Bone.....	Read Fertilizer Co., New York City.	A. Dils, Copper Hill.	7217
7281	Truck Fertilizer for Potatoes and Onions.....	" " " "	J. M. Dalrymple, Hopewell.	7281
6866	Farmers' Friend.....	" " " "	D. C. Crane, Westfield.	6866
7886	High-Grade Farmers' Friend.....	" " " "	B. F. Ward, Hainesburg.	7886
7417	Practical Potato Special.....	" " " "	" " " "	7417

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	Nitrogen.					Phosphoric Acid.					Potash.		Chlorine.	Value of 2,000 lbs. at Stations' Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.						
	From Nitrates.			Total Found.		Total Guaranteed.		Soluble in Water.			Insoluble.						Total Found.		Total Guaranteed.		Available.	
	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.										
6857	1.36	0.69	1.87	3.02	4.10	0.74	4.49	5.43	10.66	.....	5.23	7.00	5.23	7.00	2.33	2.00	\$31.15	6857				
7074	.....	4.12	4.12	4.10	1.89	4.91	6.86	12.65	7.00	.....	6.80	.....	6.80	.....	2.86	3.00	24.10	7074				
7185	.....	1.69	1.69	1.03	4.12	3.80	5.80	13.32	.....	.....	7.92	8.00	7.92	8.00	2.37	1.00	17.69	7185				
7186	1.20	.....	1.98	3.18	2.46	4.26	3.89	2.89	10.54	.....	8.15	8.00	8.15	8.00	8.32	10.00	26.44	7186				
6812	1.35	2.06	3.41	3.28	3.87	4.19	2.54	11.60	.....	.....	9.06	8.00	9.06	8.00	6.73	7.00	33.86	6812				
7282	1.25	2.01	3.26	3.28	2.28	4.01	3.01	9.30	.....	.....	6.99	5.00	6.99	5.00	10.62	10.00	27.18	7282				
7395	0.21	0.61	2.45	3.27	2.46	2.29	5.34	2.75	10.38	.....	7.63	9.00	7.63	9.00	5.85	2.00	24.42	7395				
7080	.....	2.41	2.41	2.46	5.00	4.26	4.44	13.70	.....	.....	9.26	9.00	9.26	9.00	4.56	5.00	23.19	7080				
7276	0.83	1.02	1.85	3.28	4.99	2.60	1.79	9.38	.....	.....	7.59	6.00	7.59	6.00	10.88	12.00	24.77	7276				
7486	.....	0.86	2.99	3.35	2.46	3.50	5.32	5.56	14.38	.....	8.82	7.00	8.82	7.00	2.39	2.50	32.68	7486				
7340	.....	2.78	2.78	2.46	5.76	1.82	2.24	9.82	7.00	.....	7.58	6.00	7.58	6.00	5.40	5.00	21.88	7340				
6891	0.44	0.54	0.98	0.62	1.04	1.68	2.98	5.76	.....	.....	2.72	2.00	2.72	2.00	0.71	0.50	7.52	6891				
7217	.....	1.26	1.26	0.82	4.37	2.54	2.26	9.17	8.00	.....	6.91	7.00	6.91	7.00	1.53	1.00	13.41	7217				
7281	0.62	2.46	3.08	3.28	6.07	1.85	1.10	8.52	8.00	.....	7.42	7.00	7.42	7.00	6.53	7.00	23.05	7281				
6866	.....	2.46	2.46	2.05	7.52	1.89	2.81	11.72	11.00	.....	9.41	9.00	9.41	9.00	2.41	2.16	38.2	6866				
7385	.....	3.21	3.21	3.28	3.93	1.52	5.27	8.82	7.00	.....	5.55	5.00	5.55	5.00	10.40	10.00	25.76	7385				
7417	.....	1.67	1.67	0.82	3.05	2.53	1.33	6.91	5.00	.....	5.58	4.00	5.58	4.00	7.28	8.00	17.90	7417				

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
7277	Vegetable and Vine.....	Read Fertilizer Co., New York City.	D. N. Warbasse, Hunsburg.	7277
7082	Pilgrim.....	John S. Reese & Co., Baltimore, Md.	" " "	7082
7280	Potato Phosphate.....	" " "	" " "	7280
7076	Fish Guano.....	Edward Riggs, Jr., Burlington, N. J.	H. I. Budd, Mount Holly.	7076
7284	Formula A.....	L. Sanderson, New Haven, Conn.	J. H. Denise, Freshhold.	7284
7408	Mount Rose Corn Fertilizer.....	R. Savidge, Mount Rose, N. J.	J. M. Dealympole, Hopewell.	7408
7188	Standard Phosphate.....	Scott Fertilizer Co., Elkton, Md.	T. F. Baker, Bridgeton.	7188
7189	Potato Fertilizer.....	" " "	" " "	7189
7190	Sure-Growth Superphosphate.....	" " "	" " "	7190
7283	Potato Special.....	" " "	J. H. Denise, Freshhold.	7283
7047	Soluble Tampico Guano.....	Sharpless & Carpenter, Philadelphia, Pa.	C. Kraus, Egg Harbor City	7047
7046	Gilt-Edged Potato Manure.....	" " "	" " "	7046
6923	Truck Guano.....	" " "	H. I. Budd, Mount Holly.	6923
7119	No. 1 Bone Phosphate.....	" " "	I. W. Nicholson, Camden.	7119
7170	Corn and Tomato Fertilizer.....	" " "	W. Pettit, Salem.	7170
6926	Evans' Brand Potato Manure.....	" " "	H. I. Budd, Mount Holly.	6926
7278	Swift-Sure Superphosphate for General Use.....	M. L. Shoemaker & Co., Philadelphia, Pa.	W. R. Ward, Lyons Farm.	7278
7286	" " " Potatoes.....	" " "	J. H. Denise, Freshhold.	7286

EXPERIMENT STATION REPORT.

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Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	Nitrogen.				Phosphoric Acid.				Potash.		Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.				
	From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Available.									
									Found.	Guaranteed.								
															Found.	Guaranteed.		
7277	Read's Vegetable and Vine ..	.....	.....	1.79	1.64	5.57	1.86	1.90	8.83	7.00	6.93	6.00	7.60	8.00	11.54	\$24.00	7277	
7082	Reese's Pilgrim.....	.....	.....	1.36	1.23	0.47	5.79	8.74	10.00	7.00	6.96	6.50	3.60	3.00	9.01	15.46	28.00	7082
7280	" Potato Phosphate.....	.....	.....	2.04	2.05	1.79	7.14	1.66	10.59	9.50	8.93	8.50	5.54	6.00	6.07	21.18	30.00	7280
7076	Rigg's Fish Guano.....	.....	.....	3.27	3.27	2.46	8.26	1.04	11.38	.....	9.30	8.00	3.88	3.00	4.15	23.71	30.00	7076
7284	Sanderson's Formula A.....	.....	.....	3.05	3.28	3.42	3.72	2.70	9.84	.....	7.14	6.00	4.69	6.00	1.45	22.01	34.00	7284
7408	Savidge's Mount Rose Corn.....	.....	.....	2.26	1.64	8.57	0.87	2.06	11.50	10.00	9.44	8.00	1.75	1.50	0.46	19.23	35.00	7408
7188	Scott's Standard Phosphate.....	.....	.....	1.80	1.30	1.23	6.83	2.88	11.83	.....	9.66	8.00	2.34	2.00	6.40	17.24	24.00	7188
7189	" Potato Fertilizer.....	.....	.....	2.32	2.55	1.64	3.28	8.79	15.17	.....	7.02	8.00	4.63	4.00	6.44	20.34	29.00	7189
7190	" Sure Growth Superphosphate.....	.....	.....	1.96	1.96	1.64	4.46	2.76	10.22	.....	9.22	9.00	2.49	2.00	6.26	18.88	28.00	7190
7283	" Potato Special.....	.....	.....	4.21	3.69	4.62	2.44	8.16	10.22	.....	7.06	9.00	9.82	10.00	9.55	29.46	32.00	7283
7047	S. & C.'s Soluble Tampico Guano.....	.....	.....	1.42	2.73	3.28	9.38	0.80	1.48	11.66	10.18	9.00	4.67	5.50	4.45	23.51	35.00	7047
7046	" Gilt-Edged Potato.....	.....	.....	2.50	2.50	2.46	3.28	3.56	4.86	11.19	6.83	7.00	6.66	6.00	6.54	22.25	35.00	7046
6923	" Truck Guano.....	.....	.....	3.35	7.91	8.20	7.05	8.81	9.01	7.00	7.93	4.00	4.27	4.00	3.87	35.78	50.00	6923
7119	" No. 1 Bone Phosphate.....	.....	.....	2.19	2.05	7.76	1.23	2.89	11.37	.....	8.98	8.50	3.27	3.00	5.54	19.05	25.00	7119
7170	" Corn and Tomato.....	.....	.....	1.94	1.64	2.69	5.42	4.70	12.81	.....	8.11	8.00	4.91	5.00	6.00	20.65	23.00	7170
6925	" Evans' Brand Potato.....	.....	.....	2.82	4.32	3.28	4.78	1.92	2.84	9.54	6.70	6.00	9.82	10.00	9.85	29.32	40.00	6925
7373	Shoemaker's Swift-Sure for General Use.....	.....	.....	2.28	2.97	2.46	5.10	3.76	5.41	14.30	8.86	9.00	4.19	4.00	4.57	23.94	34.50	7373
7285	" " Potatoes.....	.....	.....	1.96	2.46	5.18	8.31	5.23	13.72	11.00	8.49	8.00	6.92	6.00	6.57	25.85	33.00	7285

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
7809	Good Enough Superphosphate	M. L. Shoemaker & Co., Philadelphia, Pa.	J. H. Richardson, Rio Grande.	7809
7092	Corn Mixture.....	John I. Smith, Trenton, N. J.	J. M. Dalrymple, Hopewell.	7092
7093	XXV Brand.....	" " " "	" " " "	7093
7094	Special Potato Fertilizer.....	" " " "	" " " "	7094
7095	Corn and Truck Manure	" " " "	" " " "	7095
7096	High-Grade Potato and Truck Fertilizer.....	" " " "	" " " "	7096
7137	" " Truckers' Fertilizer.....	Rufus W. Smith, Elmer, N. J.	W. Pettit, Salem.	7137
7142	Complete Bone Fertilizer	" " " "	" " " "	7142
6906	Farmers' Pride	Smith & Flowers, Newark, N. J.	J. H. Denise, Freehold.	6906
6985	Truckers' Friend.....	" " " "	D. C. Crane, Westfield.	6985
7238	Special Vegetable Manure.	Susquehanna Fertilizer Co., Baltimore, Md.	J. H. Denise, Freehold.	7238
7287	Potato Phosphate.....	" " " "	" " " "	7287
7839	Bone Phosphate	" " " "	B. F. Ward, Hainesburg.	7839
7850	Ammoniated Bone Phosphate.....	" " " "	" " " "	7850
7191	Potato Manure.....	H. S. Tavean & Co., Baltimore, Md.	T. F. Baker, Bridgeton.	7191
7121	High-Grade Potato Phosphate	Taylor Bros., Camden, N. J.	I. W. Nicholson, Camden.	7121
7123	Lobos Guano.....	" " " "	" " " "	7123

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.		Nitrogen.				Phosphoric Acid.						Potash.		Value of 2,000 lbs. at Stations' Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
		From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available.				
												Found.	Guaranteed.			
7809	Shoemaker's Good Enough Superphos.....	0.49	.....	1.87	1.86	1.23	5.96	3.34	3.58	12.83	12.00	9.30	8.00	2.18	1.50	7809
7092	Smith's Corn Mixture.....	.....	.....	2.17	2.17	1.64	4.06	5.10	3.70	12.85	.....	9.15	7.00	3.57	3.00	7092
7088	" XXV Brand.....	.....	.....	0.97	0.97	0.83	0.62	8.12	3.50	12.24	.....	8.74	9.00	2.27	2.00	7088
7094	" Special Potato.....	.....	.....	3.18	3.18	2.46	1.60	4.36	3.15	9.11	.....	5.96	6.00	3.98	7.00	7094
7096	" Corn and Truck.....	.....	.....	2.70	2.70	2.46	7.20	2.62	1.55	11.37	.....	9.82	10.00	5.68	5.00	7096
7096	" High-Grade Potato and Truck .....	.....	.....	2.06	2.06	2.46	4.83	3.33	1.50	9.66	.....	8.16	6.00	9.80	10.00	7096
7137	R. W. Smith's H.-G. Truckers' Fertilizer .....	.....	.....	2.32	2.32	2.46	5.94	2.32	4.24	12.50	.....	8.26	7.00	5.02	6.00	7137
7142	" Complete Bone Fertilizer .....	.....	.....	2.10	2.10	2.05	6.88	2.40	4.29	13.57	11.00	9.28	9.00	3.46	3.00	7142
6808	S. & F.'s Farmers' Fride.....	2.33	.....	0.85	3.18	3.28	3.76	0.98	2.88	7.62	.....	4.74	5.00	7.76	10.00	6808
6885	" Truckers' Friend.....	2.29	.....	0.65	2.94	3.28	3.56	2.08	3.44	9.06	.....	5.62	7.00	6.35	7.00	6885
7288	Insuehanna Special Vegetable.....	.....	.....	1.89	1.89	2.05	7.83	3.33	3.81	13.52	11.00	10.71	9.00	5.76	3.00	7288
7287	" Potato Phosphate.....	.....	.....	2.09	2.09	1.64	7.08	2.28	2.87	11.63	10.00	9.26	8.00	5.64	5.00	7287
7289	" Bone Phosphate.....	.....	.....	1.42	1.42	1.64	7.08	3.56	3.78	14.37	11.00	10.64	9.00	1.32	2.00	7289
7260	" Ammon. Bone Phosphate.....	.....	.....	1.30	1.30	1.33	7.52	3.47	3.48	14.47	11.00	10.99	9.00	1.47	1.50	7260
7191	Taveau's Potato Manure.....	.....	.....	1.85	1.85	1.64	6.18	1.56	2.19	9.93	.....	7.74	8.00	9.54	9.00	7191
7121	Taylor Bros. High-Grade Potato Phos.....	.....	.....	2.15	2.15	1.64	4.77	0.67	3.18	8.62	.....	5.44	5.00	9.36	10.00	7121
7123	" Lobos Guano.....	1.89	1.18	3.07	.....	.....	2.54	6.44	15.26	24.23	.....	8.98	.....	3.22	.....	7123

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
7406	Ammoniated Dissolved Bone and Potash.....	The Taylor Provision Co., Trenton, N. J.	J. M. Dalrymple, Hopewell.	7406
7408	Complete Fertilizer for Wheat.....		" " "	7408
7406	High-Grade Corn and Truck Manure.....		" " "	7406
7289	Special Potato Fertilizer.....		J. H. Denise, Freehold.	7289
7241	High-Grade Potato and Truck Fertilizer.....		" " "	7241
7896	Pure Dissolved Bone.....	" " "	J. J. Mitchell, Troy Hills.	7896
6788	High-Grade Guano.....	I. P. Thomas & Sons Co., Philadelphia, Pa.	H. I. Budd, Mount Holly.	6788
6784	No. 1 Potato Manure.....	" " "	" " "	6784
6785	Potato and Tomato.....	" " "	" " "	6785
6964	Complete Fertilizer.....	" " "	" " "	6964
7077	Potato and Cabbage.....	" " "	" " "	7077
7124	Farmers' Choice.....	" " "	I. W. Nicholson, Camden.	7124
7192	Vegetable Manure.....	" " "	T. F. Baker, Bridgeton.	7192
7800	Wheat and Grass Compound.....	" " "	J. M. Dalrymple, Hopewell.	7800
7802	Potato Fertilizer.....	" " "	" " "	7802

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.		Nitrogen.				Phosphoric Acid.				Potash.		Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.	
		From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Available.		Found.	Guaranteed.					
							Soluble in Water.	Soluble in Ammonium Citrate.			Insoluble.				
7405	Taylor's Ammon. Diss. Bone and Potash.....	.....	1.49	1.49	1.23	3.44	4.82	3.61	11.87	8.00	8.26	.....	2.61	2.50	7405
7403	" Complete for Wheat.....	0.75	2.40	3.15	2.46	6.56	3.64	1.34	11.54	10.00	10.20	.....	3.18	2.50	7403
7406	" High-Grade Corn and Truck.....	0.78	2.25	3.03	2.46	6.42	3.48	2.71	12.61	.....	9.90	10.00	5.24	5.00	7406
7239	" Special Potato.....	0.53	1.55	2.08	2.05	4.52	5.56	3.26	13.34	.....	10.08	10.00	6.31	8.00	7239
7241	" High-Grade Potato and Truck.....	0.80	2.15	2.95	2.46	5.67	5.21	2.19	13.07	12.00	10.88	10.00	9.31	10.00	7241
7396	" Pure Dissolved Bone.....	0.64	1.83	2.47	1.64	4.83	4.21	2.49	11.53	9.00	9.04	.....	10.39	3.00	7396
6783	Thomas' High-Grade Guano.....	1.23	3.02	3.22	7.47	6.56	2.06	3.89	1.12	7.07	7.00	5.95	5.03	3.00	6783
6784	" No. 1 Potato Manure.....	0.95	2.22	3.11	2.46	5.66	2.44	3.63	11.73	11.00	8.10	9.00	7.34	6.00	6784
6785	" Potato and Tomato.....	0.71	0.22	2.32	3.15	1.23	7.32	1.16	1.46	9.94	11.00	8.48	6.33	6.00	6785
6954	" Complete Fertilizer.....	.....	1.68	1.68	0.41	7.43	2.40	2.38	12.21	11.00	9.83	9.00	3.45	1.00	6954
7077	" Potato and Cabbage.....	0.71	1.94	2.65	1.64	7.16	2.00	2.22	11.38	.....	9.16	8.00	5.72	5.00	7077
7124	" Farmers' Choice.....	.....	1.81	1.81	1.64	7.91	2.03	2.26	12.20	11.00	9.94	9.00	3.48	2.00	7124
7192	" Vegetable Manure.....	0.88	1.97	2.85	1.64	7.16	1.79	1.62	10.57	.....	8.95	9.00	5.81	4.00	7192
7800	" Wheat and Grass.....	.....	1.49	1.49	0.82	6.65	2.18	2.21	11.04	11.00	8.83	10.00	2.00	1.00	7800
7802	" Potato Fertilizer.....	0.50	2.42	3.01	1.64	7.10	1.72	2.06	10.88	10.50	8.82	9.00	6.43	6.00	7802

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
7097	Improved Superphosphate.....	I. P. Thomas & Sons Co., Philadelphia, Pa.	J. M. Dalrymple, Hopewell.	7097
7265	Grude Fish and Tobacco Stems.....	" " " "	J. M. White, New Brunswick.	7265
7263	Corn and Grain.....	" " " "	" " " "	7263
7804	Normal Bone Phosphate.....	" " " "	J. M. Dalrymple, Hopewell.	7804
7462	Sweet Potato Manure.....	" " " "	T. F. Baker, Bridgeton.	7462
6953	882 Potato Manure.....	Trenton Bone Fertilizer Co., Trenton, N. J.	H. I. Budd, Mount Holly.	6953
7268	Corn Mixture.....	" " " "	J. M. White, New Brunswick.	7268
7266	Ammoniated Dissolved Bone.....	" " " "	" " " "	7266
7099	Bone Phosphate.....	" " " "	J. M. Dalrymple, Hopewell.	7099
7100	Potato Fertilizer.....	" " " "	" " " "	7100
7102	Corn and Truck Manure.....	" " " "	" " " "	7102
7106	XX Brand.....	" " " "	" " " "	7106
7106	High-Grade Truck and Cabbage.....	" " " "	" " " "	7106
7811	Popular Phosphate.....	The J. E. Tygart Co., Philadelphia, Pa.	J. H. Richardson, Rio Grande.	7811
7814	Bone Phosphate.....	" " " "	" " " "	7814
7050	Potato Guano.....	" " " "	C. Kraus, Egg Harbor City.	7050

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	Nitrogen.				Phosphoric Acid.				Potash.		Value of 2,000 lbs. at Stations' Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.					
	From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.				Available.				
														Found.	Guaranteed.	Found.	Guaranteed.	
7097	Thomas' Improved Superphosphate.....	0.60	.....	1.46	2.06	0.41	7.20	2.05	3.00	13.35	13.00	9.25	10.00	2.61	\$19.44	7097		
7265	" Crude Fish and Tobacco.....	.....	1.13	0.99	4.92	.....	0.98	4.46	0.48	5.91	.....	5.43	.....	1.31	1.12	20.98	7265	
7263	" Corn and Grain.....	0.20	.....	1.26	1.46	0.82	6.83	2.82	2.87	11.52	.....	8.95	9.00	1.93	4.22	16.68	7263	
7804	" Normal Bone Phosphate.....	0.20	.....	1.13	1.33	1.23	4.57	2.86	1.94	9.37	9.50	7.43	8.50	2.79	2.71	15.17	7804	
7462	" Sweet Potato Manure.....	1.04	.....	1.18	2.22	1.64	9.32	0.92	1.26	11.49	.....	10.24	9.00	10.66	10.29	27.46	7462	
6853	Trenton \$32 Potato Manure.....	0.50	.....	1.24	1.84	1.64	7.43	1.82	2.70	11.45	.....	8.75	8.00	9.29	10.74	24.16	6853	
7268	" Corn Mixture.....	0.45	.....	1.65	2.10	1.64	4.13	8.40	1.70	9.23	.....	7.53	7.00	3.97	5.66	18.37	7268	
7266	" Ammoniated Dissolved Bone .....	.....	.....	2.57	2.57	1.64	6.92	2.74	1.15	10.81	.....	9.66	8.00	2.30	5.45	20.35	7266	
7099	" Bone Phosphate.....	0.22	.....	2.13	2.36	1.64	7.49	4.02	2.45	13.96	.....	11.51	10.00	3.31	5.66	23.30	7099	
7100	" Potato Fertilizer.....	0.52	.....	2.55	3.07	2.46	4.73	4.22	2.43	11.38	.....	8.95	10.00	10.24	10.30	28.57	7100	
7102	" Corn and Truck Manure.....	0.85	.....	2.88	3.23	2.46	7.59	8.76	2.13	13.48	.....	11.35	10.00	5.49	5.13	27.24	7102	
7106	" XX Brand.....	0.24	.....	1.75	1.99	0.82	6.74	1.87	2.31	10.92	.....	8.61	9.00	2.40	5.22	18.10	7106	
7105	" High-Grade Truck and Cabbage.....	2.81	.....	3.85	6.66	6.56	3.67	3.88	2.14	9.69	.....	7.55	8.00	4.92	4.90	31.97	7105	
7811	Tygart's Popular Phosphate.....			0.96	0.96	0.82	1.23	3.27	3.79	8.29	9.00	4.50	7.00	2.45	5.75	11.37	25.00	7811
7814	" Bone Phosphate.....	0.21	0.25	1.51	1.97	1.85	6.92	1.49	1.57	9.98	11.00	8.41	9.00	4.65	2.48	19.62	28.00	7814
7050	" Potato Guano.....		0.23	1.88	2.16	2.05	6.55	1.12	2.27	9.94	8.00	7.67	7.00	7.79	7.71	22.46	35.00	7050

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
6935	Popular Phosphate.....	The Tygart-Allen Fertilizer Co., Philadelphia, Pa.	H. I. Budd, Mount Holly.	6965
6938	Fish, Bone and Potash.....	" " " " " "	" " " " " "	6968
6957	Nitro-Phosphate.....	" " " " " "	" " " " " "	6957
7080	Superior Ground Fish Guano.....	" " " " " "	" " " " " "	7080
7002	Soluble Marine Guano.....	" " " " " "	J. C. Griscom, Woodbury.	7002
7003	Potato Manure.....	" " " " " "	" " " " " "	7003
7174	Farmers' Bone Phosphate.....	" " " " " "	W. Pettit, Salem.	7174
7172	Star Bone Phosphate.....	" " " " " "	" " " " " "	7172
7173	" Guano.....	" " " " " "	" " " " " "	7173
7874	Big Bonanza.....	Walker Stratman & Co., Pittsburg, Pa.	W. R. Ward, Lyons Farms.	7874
6841	Potato Manure.....	Geo. M. Wells, Moorestown, N. J.	H. I. Budd, Mount Holly.	6841
6842	" and Cabbage Manure.....	" " " " " "	" " " " " "	6842
6843	Fish Guano.....	" " " " " "	" " " " " "	6843
7180	Ten Per Cent. Fertilizer.....	J. Wenderoth & Sons, Camden, N. J.	I. W. Nicholson, Camden.	7180
7182	Potato Fertilizer.....	" " " " " "	" " " " " "	7182
7181	25 Fertilizer.....	" " " " " "	" " " " " "	7181
7183	Favorite.....	" " " " " "	" " " " " "	7183

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	Nitrogen.										Phosphoric Acid.				Potash.		Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
	From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.			Total Found.	Total Guaranteed.	Available.		Found.	Guaranteed.					
						Soluble in Ammonium Citrate.	Insoluble.												
6955	Tygart-Allen's Popular Phosphate.....	.....	.....	1.16	1.16	0.82	5.64	1.66	1.34	8.64	9.00	7.30	6.00	2.28	2.00	8.31	\$13.87	6955	
6958	" Fish, Bone and Potash.....	.....	.....	3.18	3.18	3.28	5.27	2.13	1.44	8.84	8.00	7.40	5.00	3.14	3.00	9.49	20.45	6958	
6957	" Nitro-Phosphate.....	.....	.....	2.09	2.09	1.85	7.23	1.02	3.49	11.74	13.00	8.25	8.50	2.64	2.50	2.11	18.70	6957	
7080	" Superior Ground Fish.....	.....	.....	1.47	1.47	1.64	5.90	1.03	1.52	8.45	.....	6.93	5.00	1.84	1.62	6.32	14.01	7080	
7002	" Soluble Marine Guano.....	.....	.....	1.36	3.63	3.69	6.65	1.22	0.98	8.85	9.00	7.87	7.00	6.96	5.00	6.12	25.25	7002	
7008	" Potato Manure.....	.....	.....	1.58	3.22	3.28	6.29	0.87	1.55	8.71	9.00	7.16	6.00	7.86	9.00	5.14	24.42	7003	
7174	" Farmers' Bone Phosphate.....	.....	.....	1.97	1.97	1.64	7.42	1.33	1.44	10.19	.....	8.75	8.00	2.22	2.00	3.92	17.72	7174	
7172	" Star Bone Phosphate.....	.....	.....	2.15	2.15	1.85	7.64	0.66	3.17	11.47	9.50	8.30	8.50	2.55	2.50	2.10	18.72	7172	
7173	" " Guano.....	.....	.....	1.88	2.07	2.25	8.21	0.92	2.40	11.53	9.50	9.13	7.50	3.01	3.50	2.47	19.48	7173	
7874	W., S. & Co.'s Big Bonanza.....	.....	.....	2.20	2.20	1.64	8.17	2.05	2.47	12.69	15.00	10.22	11.00	2.56	2.00	0.49	20.90	7874	
6841	Wells' Potato Manure.....			0.60	1.16	1.69	5.54	3.38	5.40	1.16	1.44	8.60	6.56	6.00	8.95	8.00	8.69	25.93	6841
6842	" Potato and Cabbage.....	.....	.....	0.24	1.82	2.06	7.60	0.65	2.19	10.44	.....	8.25	6.00	3.68	6.00	8.65	19.09	6842	
6843	" Fish Guano.....			0.44	1.31	1.75	1.64	8.26	1.37	2.45	12.03		9.63	8.00	2.07	2.00	2.07	18.30	6843
7180	Wendroth's Ten Per Cent. Fertilizer.....	.....	.....	2.26	3.32	2.77	8.35	8.20	4.83	0.83	1.26	6.92	7.00	3.25	3.00	3.24	33.47	7180	
7182	" Potato Fertilizer.....	.....	.....	1.24	1.22	1.40	3.86	3.28	5.99	2.45	2.46	10.90	9.00	5.03	5.00	4.90	25.73	7182	
7181	" \$25 Fertilizer.....				2.15	2.15	1.64	7.50	3.17	4.09	14.76	12.00	10.67	10.00	1.72	1.00	1.77	20.85	7181
7183	" Favorite.....	.....	.....	0.81	4.93	5.74	0.73	5.62	7.87	13.72	11.00	6.35	5.00	6.10	4.00	6.96	31.41	7183	

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
7158	Special Potato Manure.....	West Jersey Marl and Trans Co., Woodbury, N. J.	W. Pettit, Salem.	7158
7156	Our Mixture for All Crops.....	" " " " " " " "	" "	7156
7004	Chester Valley Special Potato.....	W. E. Whann, William Penn, Pa.	J. C. Griscom, Woodbury.	7004
7006	Ammoniated Superphosphate.....	" " " " " " " "	" "	7006
7197	Royal Sweet Potato Manure.....	M. E. Wheeler & Co., Rutland, Vt.	T. F. Baker, Bridgeton.	7197
7292	High Grade Potato Manure.....	" " " " " " " "	J. M. Dalrymple, Hopewell.	7292
7084	" " Corn Fertilizer.....	" " " " " " " "	D. N. Warbasse, Hantsburg.	7084
7196	Corn Fertilizer.....	W. Wilde, Vineland, N. J.	T. F. Baker, Bridgeton.	7196
7221	Prolific Crop Producer.....	Williams & Clark Fertilizer Co., New York City.	A. Dills, Copper Hill.	7221
7899	Royal Bone Phosphate.....	" " " " " " " "	J. J. Mitchell, Troy Hills.	7899
7086	Universal Ammoniated Dissolved Bone.....	" " " " " " " "	D. N. Warbasse, Hantsburg.	7086
7089	Potato, Hop and Tobacco Manure.....	" " " " " " " "	" " " "	7089
7042	" Phosphate.....	" " " " " " " "	" " " "	7042
7041	High-Grade Special Potato, Onion and Cabbage.....	" " " " " " " "	" " " "	7041
7198	Potato Fertilizer.....	O. W. Worstell, Millville, N. J.	T. F. Baker, Bridgeton.	7198
7288	High-Grade Standard Ammoniated Diam. Bone.....	F. B. Young, Pennington, N. J.	J. M. Dalrymple, Hopewell.	7288
7284	" " Cereal Dissolved Bone Phosphate.....	" " " " " " " "	" " " "	7284

Complete Fertilizers
Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.		Nitrogen.				Phosphoric Acid.						Potash.		Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.	
		From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.			Insoluble.	Total Found.	Total Guaranteed.	Available.				
							Soluble in Ammonium Citrate.	Soluble.	Found.				Guaranteed.				Found.	Guaranteed.
7158	West Jersey Special Potato.....	.....	.....	2.31	2.31	2.05	6.20	1.22	1.98	9.40	.....	7.42	5.00	10.19	10.00	7.34	830.00 7158
7156	" " Our Mixture for All Crops.....	.....	.....	2.14	2.14	2.05	7.04	1.13	2.28	10.45	.....	8.17	6.00	4.05	4.00	6.33	24.00 7156
7004	Whann's Chester Valley Special Potato.....	0.74	.....	2.31	3.05	2.05	6.70	1.25	2.56	10.51	11.00	7.95	8.00	5.32	5.00	6.44	32.00 7004
7005	" Ammoniated Superphosphate.....	.....	.....	1.96	1.96	1.23	8.22	1.65	2.81	12.68	9.00	9.87	7.00	2.26	3.00	4.37	28.00 7005
7197	Wheeler's Royal Sweet Potato.....	0.44	.....	1.81	2.25	2.05	8.75	0.91	0.48	10.14	10.00	9.66	8.00	8.24	8.00	7.48	33.00 7197
7292	" High-Grade Potato.....	0.66	.....	1.59	2.25	2.05	7.13	1.89	1.92	10.94	9.00	9.02	8.00	3.84	3.25	3.13	32.00 7292
7084	" " Corn.....	.....	.....	2.51	2.51	1.64	6.60	2.22	2.16	10.98	9.00	8.82	8.00	2.52	2.00	3.96	23.00 7084
7196	Wilde's Corn Fertilizer.....	.....	.....	1.80	1.80	1.64	4.58	5.25	2.60	12.43	.....	9.83	9.00	6.81	6.00	8.56	23.00 7196
7221	W. & C.'s Prolific Crop Producer....	.....	.....	1.07	1.07	0.82	2.02	4.63	3.08	9.73	7.00	6.65	6.00	1.26	1.00	2.84	25.00 7221
7399	" Royal Bone Phosphate.....	.....	.....	1.54	1.54	1.03	4.00	4.23	3.14	11.36	8.00	8.22	7.00	1.94	2.00	2.50	30.00 7399
7086	" Universal Ammon. Diss. Bones.....	.....	0.31	1.83	2.14	1.64	4.83	4.93	2.77	12.53	9.00	9.76	8.00	2.07	2.00	2.41	29.00 7086
7089	" Potato, Hop and Tobacco.....	.....	0.21	2.01	2.22	2.05	3.96	5.07	4.42	13.45	9.00	9.03	8.00	3.30	3.00	3.36	29.00 7089
7042	" " Phosphate.....	.....	.....	2.77	2.77	2.46	5.27	1.54	2.24	9.05	7.00	6.81	6.00	4.99	5.00	5.21	33.00 7042
7041	" H.-G. Special Potato, Onion, etc.....	1.03	0.68	1.89	3.60	3.69	4.50	2.87	4.05	11.42	8.00	7.37	7.00	7.14	7.00	6.42	38.00 7041
7198	Worshall's Potato Fertilizer.....	0.22	.....	1.44	1.66	1.64	5.28	4.01	2.82	12.11	.....	9.29	9.00	7.46	7.00	1.13	32.00 7198
7283	Young's High-Grade Stand. Am. Diss. Bone....	.....	.....	1.23	1.23	1.23	6.77	1.43	1.80	10.00	10.50	8.20	8.50	1.36	1.50	3.28	26.00 7283
7284	" " Cereal Diss. Bone Phos....	.....	.....	1.12	1.12	0.82	5.15	1.08	1.27	7.50	7.00	6.23	6.00	2.24	2.00	5.17	23.00 7284

Ground Bone
Furnishing Nitrogen and Phosphoric Acid.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
7419	Bone Flour.....	Armour & Co., Chicago, Ill.	C. C. Hulbert, Matawan.	7419
6915	Domestic Animal Ground Bone.....	Baugh & Sons Co., Philadelphia, Pa.	H. I. Budd, Mount Holly.	6915
7295	Electric Raw Bone, Fine.....	The Berg Co., Philadelphia, Pa.	J. M. Dainty, Hopewell.	7295
6798	Ground Bone.....	Bowker Fertilizer Co., New York City.	J. H. Denise, Freehold.	6798
6878	Pure Raw Bone Meal.....	Brimfield & Foster, Colons, Md.	C. Kraus, Egg Harbor City.	6878
7213	" Ground Bone.....	Chandler, Russell & Chandler, Newark, N. J.	A. Ditta, Copper Hill.	7213
7886	" Fine Ground Bone.....	E. Frank Coe Co., New York City.	J. J. Mitchell, Troy Hills.	7886
7480	" Bone.....	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.	W. R. Ward, Lyons Farms.	7480
7472	" Ground Bone.....	I. S. Curtis, Frenchtown, N. J.	R. Budd, Frenchtown.	7472
7025	Steamed Bone Dust.....	Cooper Glue Co., New York City.	D. N. Warbasse, Hounsburg.	7025
7479	Pure Ground Bone.....	L. B. Darling Fertilizer Co., Pawtucket, R. I.	D. C. Lewis, Cranbury.	7479
7007	Steamed Ground Bone.....	Eastern Farm Supply Association, Montclair, N. J.	D. C. Crane, Westfield.	7007
7292	Ground Bone.....	S. M. Hess & Bro., Reading, Pa.	A. Ditta, Copper Hill.	7292
7144	Bone Meal.....	Hires & Co., Quinton, N. J.	W. Pettit, Salem.	7144
7425	Pure Ground Bone.....	Samuel Lederer & Son, New Brunswick, N. J.	J. M. White, New Brunswick.	7425
7882	" ".....	The Mapes F. & P. Guano Co., New York City.	B. F. Ward, Hainesburg.	7882

Ground Bone Furnishing Nitrogen and Phosphoric Acid.

Station Number.	Mechanical Analysis.				Chemical Analysis.		Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Depot.	Station Number.
	Finer than 1-60th in.	Finer than 1-25th in.	Finer than 1-12th in.	Coarser than 1-12th in.	Nitrogen.	Phosphoric Acid.			
7419	Armour's Bone Flour.....	97	3	.....	8.16	26.26	\$34.61	\$23.50	7419
6915	Baugh's Domestic Animal Ground Bone.....	59	25	15	1	2.09	28.17	27.00	6915
7295	Berg's Electric Raw Bone, Fine.....	37	24	27	12	4.19	26.38	32.00	7295
6798	Bowker's Ground Bone.....	69	19	12	.....	2.07	24.04	31.00	6798
6878	Brunfield & Foster's Pure Raw Bone Meal.....	28	30	36	8	4.01	24.48	30.00	6878
7213	C. R. & C.'s Pure Ground Bone.....	37	26	21	16	2.96	24.90	28.00	7213
7886	Coe's Pure Fine Ground Bone.....	34	12	4	.....	2.62	33.19	38.00	7886
7480	Crocker's Pure Bone.....	37	25	27	11	8.91	27.39	36.00	7480
7472	Curtis' Pure Ground Bone.....	32	29	36	3	8.96	26.24	29.00	7472
7026	Cooper's Steamed Bone Dust.....	68	13	9	10	1.63	30.43	\$25.83	7026
7479	Darling's Pure Ground Bone.....	75	16	9	.....	8.00	30.19	29.00	7479
7007	Steamed Ground Bone.....	61	24	10	5	2.96	30.45	30.00	7007
7292	Hess' Ground Bone.....	42	26	32	.....	8.23	23.57	29.00	7292
7144	Hires' Bone Meal.....	74	15	9	2	2.80	30.37	26.00	7144
7425	Lederer's Pure Ground Bone.....	29	25	20	26	8.86	21.25	28.00	7425
7332	Mapes' Pure Ground Bone.....	59	12	14	15	2.85	27.62	34.00	7332

* Price per ton in carload lots.

Ground Bone Furnishing Nitrogen and Phosphoric Acid.

Station Number	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number
7116	Button Bone.....	L. Moritz, Philadelphia, Pa.	I. W. Nicholson, Camden.	7116
7456	Pure Bone.....	Mixner & Mickel, Bridgeton, N. J.	T. F. Baker, Bridgeton.	7456
7487	Ground Bone.....	Preston Fertilizer Co., Greenpoint, L. I.	W. R. Ward, Lyons Farms.	7487
7169	Pure Ground Animal Bone.....	Moro Phillips Chemical Co., Philadelphia, Pa.	W. Pettit, Salem.	7169
7149	Swift-Sure Bone Meal.....	M. L. Shoemaker & Co., Philadelphia, Pa.	" "	7149
6981	Pure Raw Ground Bone.....	" " " "	D. C. Crane, Westfield.	6981
7286	Pure Ground Bone.....	Susquehanna Fertilizer Co., Baltimore, Md.	J. H. Denise, Freehold.	7286
6947	Steamed Bone.....	Swift & Co., Chicago, Ill.	H. I. Budd, Mount Holly.	6947
6906	Bone Meal.....	The Taylor Provision Co., Trenton, N. J.	J. H. Denise, Freehold.	6906
7482	Ground Bone.....	" " " "	D. C. Lewis, Cranbury.	7482
7301	Pure Ground Animal Bone.....	I. P. Thomas & Sons Co., Philadelphia, Pa.	J. M. Dalrymple, Hopewell.	7301
7053	Ground Bone.....	" " " "	Station.	7053
7287	Pure Fine-Ground Bone.....	Trenton Bone Fertilizer Co., Trenton, N. J.	J. M. White, New Brunswick.	7287
6988	Americus Ground Bone.....	Williams & Clark Fertilizer Co., New York City.	H. C. McLean, Pound Brook.	6988
6960	Fine-Ground Bone.....	Samuel Winterbottom & Co., Egg Harbor City N. J.	C. Kraus, Egg Harbor City.	6960
6961	Bone Sawings.....	" " " "	" " " "	6961

Ground Bone
Furnishing Nitrogen and Phosphoric Acid.

Station Number.	Mechanical Analysis.					Chemical Analysis.		Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Depot.	Station Number.
	Finer than 1-60th In.	Finer than 1-25th In.	Finer than 1-12th In.	Coarser than 1-12th In.		Nitrogen.	Phosphoric Acid.			
7116	46	18	25	11		3.23	26.58	\$26.85	\$33.00	7116
7456	53	24	20	3		4.21	22.98	29.20	30.00	7456
7487	52	25	17	6		2.97	27.28	29.57	30.00	7487
7169	23	35	35	7		4.09	20.78	23.53	28.00	7169
7149	71	24	5			6.16	21.21	35.60	31.00	7149
6981	40	24	26			4.39	23.84	29.61	34.00	6981
7286	21	24	33	17		4.15	23.34	23.42	34.00	7286
6847	84	12	4			2.97	26.36	33.00	*21.50	6847
6906	74	8	14	4		2.65	26.52	30.14	*22.50	6906
7482	76	16	7	2		2.50	27.82	32.01	26.00	7482
7801	15	22	56	7		4.16	24.56	23.81	32.00	7801
7058	35	37	23			3.94	23.96	28.05	*25.00	7058
7267	42	31	27			4.22	22.20	27.79	32.00	7267
6983	53	24	21	2		2.57	24.04	26.24	*24.00	6983
6960	26	31	40	3		4.27	23.62	26.34	29.00	6960
6961	94	6				3.80	26.80	36.67	32.00	6961

* Price per ton in carload lots.

Miscellaneous Fertilizers
Furnishing Nitrogen, Phosphoric Acid or Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
6872	Union Dissolved Bone.....	Bowker Fertilizer Co., New York City.	C. Kraus, Egg Harbor City.	6872
7880	Union Fresh Ground Bone.....	" " " "	J. J. Mitchell, Troy Hills.	7880
6904	Pure Dissolved Animal Bone.....	Chemical Co. of Canton, Baltimore, Md.	C. Kraus, Egg Harbor City.	6904
7088	Ammoniated Ground Bone.....	Albert Nelson, Allentown, N. J.	J. M. Dalrymple, Hopewell.	7088
7122	Animal Bone.....	Taylor Bros., Camden, N. J.	I. W. Nicholson, Camden.	7122
6787	Improved Superphosphate Without Potash.....	I. P. Thomas & Sons Co., Philadelphia, Pa.	H. I. Budd, Mount Holly.	6787
7101	Dissolved Bone.....	Trenton Bone Fertilizer Co., Trenton, N. J.	J. M. Dalrymple, Hopewell.	7101
7209	Animal Bone and Potash.....	Lister's A. C. Works, Newark, N. J.	A. Ditta, Copper Hill.	7209
7269	Alkaline Bone, No. 2.....	Moro Phillips Chemical Co., Philadelphia, Pa.	J. M. White, New Brunswick.	7269
7262	Crown Phosphate.....	J. S. Reese & Co., Baltimore, Md.	" " " "	7262
7138	Superphosphate and Potash.....	R. W. Smith, Elmer, N. J.	W. Pettit, Salem.	7138
7143	Double-Strength Fertilizer.....	" " " "	" " " "	7143
7157	Grain Grower.....	West Jersey Marl & Trans. Co., Woodbury, N. J.	" " " "	7157
7085	High-Grade Fruit Fertilizer.....	M. E. Wheeler & Co., Rutland, Vt.	D. N. Warbase, Hainesburg.	7085
7224	Dissolved Bone and Potash.....	Williams & Clark Fertilizer Co., New York City.	B. F. Ward, Hainesburg.	7224

Miscellaneous Fertilizers Furnishing Nitrogen, Phosphoric Acid or Potash.

EXPERIMENT STATION REPORT.

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Station Number.	Nitrogen.					Phosphoric Acid.					Potash.		Chlorine.	Value of 2,000 lbs. at Stations' Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
	From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.				
6872				2.92	1.64	3.70	6.43	9.70	19.83	12.00	10.13	10.00	.....	\$23.20	\$28.00	6872
7880				3.00	2.46	1.52	5.28	12.74	19.54	18.00	6.80	5.00	.....	20.98	29.00	7880
6904				2.45	2.05	6.40	8.09	7.91	17.40	.....	9.49	12.00	.....	20.46	32.00	6904
7088				6.22	4.92	0.63	4.81	9.99	15.38	13.75	5.49	.....	.....	27.42	25.00	7088
7122				2.39	2.05	7.26	1.26	3.64	12.16	.....	8.52	7.00	.....	17.53	24.00	7122
6787	0.86	1.17	2.02	0.82	6.38	8.30	3.22	14.90	14.00	.....	9.68	12.00	.....	18.31	25.00	6787
7101				3.98	2.46	8.88	8.21	3.85	15.44	.....	12.09	13.00	.....	25.78	25.00	7101
7209						6.70	2.43	1.19	10.32	10.00	9.13	9.00	5.43	15.41	22.00	7209
7259						6.14	2.86	2.26	11.26	10.00	9.00	9.00	2.14	12.73	16.00	7259
7282						7.88	1.97	3.20	13.05	13.00	9.85	.....	1.55	13.52	25.00	7282
7188						1.14	8.49	8.71	13.34	.....	9.63	11.00	2.44	14.46	13.50	7188
7143						12.24	3.49	1.96	17.69	.....	15.73	15.00	5.65	23.17	21.00	7143
7157						9.42	1.48	1.78	12.68	.....	10.90	10.00	1.78	14.30	15.00	7157
7085						4.54	3.98	3.26	11.73	11.00	8.47	10.00	8.04	17.85	25.00	7085
7254						5.16	4.27	5.18	14.61	11.00	9.43	10.00	2.03	14.44	25.00	7254

Superphosphate of Lime.

7481. Acid Phosphate. S. M. Hess & Bro., Reading, Pa. Sent by D. C. Lewis, Cranbury.

6995. Soluble Bone Phosphate. The Keystone Chemical Manufacturing Co., Camden, N. J. Sent by J. C. Griscom, Woodbury.

7155. Acid Phosphate. New Jersey Farmers' Exchange, Elmer, N. J. Sent by W. Pettit, Salem.

7260. Soluble Bone. Moro Phillips Chemical Co., Philadelphia, Pa. Sent by J. M. White, New Brunswick.

6945. Dissolved Phosphate of Lime. John S. Reese & Co., Baltimore, Md. Sent by H. I. Budd, Mount Holly.

	7481	6995	7155	7260	6945
Phosphoric Acid—					
Soluble in Water.....	11.16	7.46	11.26	10.20	10.88
Soluble in Ammonium Citrate.....	8.17	5.16	2.01	2.85	3.60
Insoluble	3.46	3.57	2.22	2.90	2.97
Total	17.79	16.19	15.49	15.95	17.45
Available	14.33	12.62	13.27	13.05	14.43
Selling Price Per Ton.....	\$12.00	\$15.00	\$12.00	\$14.00	\$13.00

Wood Ashes.

7109. Munroe, Lalor & Co., Oswego, N. Y. Sent by P. Staats, Bound Brook.

7224. Munroe, Lalor & Co., Oswego, N. Y. Sent by J. H. Denise, Freehold.

7315. Easton Lime Co., Easton, Pa. Sent by P. Staats, Bound Brook.

	7109	7224	7315
Phosphoric Acid.....	1.74	1.43	1.64
Potash.....	6.02	4.53	3.61
Lime	35.06	28.00	42.40
Valuation Per Ton.....	\$7.59	\$5.86	\$5.09
Selling Price Per Ton.....	\$12.00	\$13.00	\$13.00

Sundry Materials.

6777. Tobacco Stems—Green. Sent from Duke's Farm, Somerville. It contains 2.04 per cent. of nitrogen (1.11 of which is nitrate), 0.51 per cent. of phosphoric acid and 7.34 per cent. of potash.

6790. Green Marl, representing a stratum 6 to 8 feet thick. Sent by J. E. Kuhns, Cliffwood. It contains 13.58 per cent. of water, 0.30 of phosphoric acid, 1.04 of potash (soluble in acid), 2.14 of lime and 9.58 of organic matter.

6791. Red Rock Marl. Also sent by J. E. Kuhns, Cliffwood. It represents a stratum 8 feet thick overlying the green marl (sample No. 6790), but still 5 feet below the surface. It contains 17.37 per cent. of water, 0.25 of phosphoric acid, 0.97 of potash (soluble in acid), 0.48 of lime and 6.32 of organic matter.

6828. Crematory Garbage. Trenton Crematory. Sent by C. W. Risdon. Selling price per ton, \$10.00. This represents a product resulting from the treatment of city garbage, which includes all forms of vegetable matter, animal matter, bones, etc., etc., usually found in garbage. One hundred tons are produced annually from about 1,400 tons of garbage. The product contains 19.60 per cent. of water, 0.64 of nitrogen, 3.15 of phosphoric acid, 1.36 of potash, 1.60 of chlorine, 9.38 of lime, and 13.54 of organic matter.

6829. Nitrate of Potash from Tobacco Extracts. Louisville Spirit Cured Tobacco Co., Louisville, Ky. Sent by A. G. Robinson. It contains 10.41 per cent. of nitrogen (9.94 of which is nitrate) and 40.78 per cent. of potash.

7062. Stone Lime. G. W. & H. Corson, Plymouth Meeting, Pa. Sent by H. I. Budd, Mount Holly. It contains 56.40 per cent. of lime.

7063. National Plant Food. National Plant Food Co., Washington, D. C. Sent by H. I. Budd, Mount Holly. Selling price per ton, \$17.00. It contains 23.84 per cent. of phosphoric acid (of which 22.82 is insoluble in ammonium citrate solution) and 0.21 per cent. of potash, substantially as guaranteed.

This material has been sold in some sections of the State for as high as \$20 per ton. In response to many inquiries respecting it, the following information has been sent: "This is an untreated phosphate, probably a soft phosphate of Florida, or at least a material very similar in its character. At the price asked it is a very expensive source of phosphoric acid, and while it will doubtless become available in the soil in time, it is folly for farmers to pay at the rate of from 3½ to 4 cents per pound for phosphoric acid in such products when they can purchase 'available' phosphoric acid in the form of superphosphate for the same price per pound."

7474. Thomas Phosphate Powder. Thomas Phosphate Syndicate, Germany. It contains 17.60 per cent. of phosphoric acid, of which 0.18 is soluble in water and 5.67 soluble in ammonium citrate solution at 100° F.

This material is a by-product from the manufacture of steel from phosphatic iron ore. It has been imported from Germany, where the results from its use in the field have led chemists to believe that the regular method for the determination of available phosphoric acid does not show the true availability in this particular material. After due study a more applicable method may be adopted here.

7476. Wool Waste from Philadelphia Mills. Sent by Allen M. Batten, Swedesboro. Selling price, \$3.00 per ton, f. o. b., Philadelphia. It contains 2.34 per cent. of nitrogen, 0.62 of phosphoric acid, 2.25 of potash, and 0.47 of chlorine.

7483. Sea Pumpkin. Sent by A. S. Scull, Linwood. It contains 7.29 per cent. of water, 1.47 of nitrogen, 0.50 of phosphoric acid, 0.37 of potash, 13.97 of organic matter, and 78.74 of total mineral matter.

This is a vegetable product growing in the inlets from the sea, in masses from a few ounces to thirty or forty pounds in weight, when wet. It is drawn out upon shore, where it is broken up and allowed to dry through the agency of the sun and wind, before being carted away. The sample analysed represents some which had been so treated. In this condition it is quite as rich in phosphoric acid and potash, and richer in nitrogen, than the average yard manure.

7480. Tankage. L. B. Darling Fertilizing Co., Pawtucket, R. I. Sent by D. C. Lewis, Cranbury. Selling price per ton, \$25.00, In 100 parts 59 are finer than 1-50 inch, 23 finer than 1-25 inch, and 16 finer and 2 coarser than 1-12 inch. It contains 5.40 per cent. of nitrogen, and 16.21 per cent. of phosphoric acid. Valuation per ton, \$27.57.

ANALYTICAL METHODS.

The Availability of Organic Nitrogen.

The increase of the fertilizer trade and the consequent utilization of any waste products available in that trade may offer in some cases a temptation to make use of inferior raw materials in the compounding of fertilizers. This would be most likely in the case of ammo-

niates, which, as a rule, are the most expensive ingredients in fertilizer manufacture. If garbage—tankage, leather, wool waste, felt waste and other materials of similar nature were used as the source of the nitrogen supply in complete fertilizers, the ordinary methods of chemical analysis would show a relatively high content of nitrogen, but the results obtained in the field would not be in proportion to what would be expected from the analysis. Such nitrogen is in such an unavailable form that years of patient waiting may be necessary before any marked benefit would be noticeable.

The present laboratory methods do not attempt to point out the source of the organic nitrogen in fertilizers. In some cases a simple inspection of the fertilizer will tell the source of its nitrogen, but very often, if inferior materials were employed, either the nature of the product used or the skill of the manufacturer would render detection by mere visual inspection almost impossible.

While it is admitted that the only true test of availability is one in which the fertilizers under examination are tried on actual crops, and nature allowed to be the interpreter, still such a method is so time-consuming as to be almost impracticable with most station workers. While it is impossible to imitate exactly the action of the soil on a small amount of fertilizing material, the relative solubility of the materials under examination can be determined in the laboratory, and compared with their relative crop-producing power, and if these methods give concordant results, the chemical method may be used as a test of the availability of the nitrogen in mixed goods, which could not be tested otherwise.*

For these reasons chemists have been attempting to solve this problem for a number of years. As early as 1882, Stutzer and Klinkenberg† suggested a method where the digestion was effected by a solution of pulverized pepsin in hydrochloric acid. Drs. Shepard and Chazal,‡ of South Carolina, applied this method to some peculiarly-American ammoniates, and Dr. Jenkins,§ of Connecticut, has carried the work still further by also testing the method of putrefactive fermentation proposed by Morgen.¶

* Rept. Conn. Expt. Station, 1885, p. 116.

† Jour. für Landwirthschaft, 1882, p. 363.

‡ Rept. Conn. Expt. Station, 1885, p. 117.

§ Ditto, 1885, pp. 115-132; 1886, pp. 80-89; 1893, pp. 218-237; 1894, pp. 73-112; 1895, pp. 99-116.

¶ Landwirth. Versuchs-Stationen, 1880, p. 50.

The conclusions from the experiments of these investigators show that the method of pepsin digestion divides "organic nitrogenous matters into two classes. In one class more than one-half of the nitrogen is soluble, in the other scarcely more than one-third is soluble. To the first class belong all the materials whose nitrogen is known to be readily available in the usual sense. Of the second class, the most soluble are leathers variously manipulated, which are comparatively worthless as ingredients of commercial fertilizers. To some extent this method is therefore a measure of the agricultural value of nitrogen."*

After a carefully-conducted series of vegetation tests in a large number of nitrogenous materials, and tests by the pepsin-hydrochloric acid method in the same, the conclusion was reached that the solubility of the nitrogen of these samples in pepsin solution was a fairly good guide as to the relative availability of the nitrogen to the plant, except in the case of horn and hoof and dissolved leather.

In the light of these investigations, a number of the complete fertilizers analysed by this Station in 1895, were tested by this method. Forty-nine brands were examined, and although they represent only a small proportion (18 per cent.) of the total number analysed during the year, forty-three manufacturers are represented, and it is believed that the results secured are indicative of the average composition of New Jersey samples.

METHOD.—One gram of the fertilizer was washed on a filter with 250 cc. of cold water to remove soluble salts, and the residue was treated with the pepsin solution as described in the Rept. Conn. Expt. Station for 1893, p. 219. It is unnecessary to give the individual results, a summary of which follows:

In 3 brands between 80 and 90 per cent. of the nitrogen was soluble in pepsin.									
" 13	"	"	70	"	80	"	"	"	"
" 16	"	"	60	"	70	"	"	"	"
" 11	"	"	50	"	60	"	"	"	"
" 4	"	"	40	"	50	"	"	"	"
" 2	"	under	40	"	"	"	"	"	"

It will be seen from the above that six, or 12 per cent., of the fertilizers examined had such a low nitrogen solubility that they must be regarded with suspicion. These results indicate that there are suspicious fertilizers on the market. Their number, however, is not

* Rept. Conn. Expt. Station, 1893, p. 218.

great, and the suspected fertilizers, with one exception, represent the product of small manufacturers whose output does not exceed fifty tons per annum.

Solubility of Ammoniates in Pepsin Solution.

To increase the data on this subject a number of tests were made at this Station on certain well-known ammoniates, both in the pure commercial state and in certain special mixtures of our own compounding, where the source of the organic nitrogen was known. A description of the materials tested follows :

6311. Bone Sawings. A very clean, hard raw bone.

6176. Steamed Bone. In a fine mechanical condition, a product of a large Western packing-house.

887. Cotton-seed Meal. An excellent decorticated product.

6331. Dried Ground Fish.

6653. Tobacco Dust. Sweepings from tobacco factory.

6602. King Crab (*Limulus Polyphemus*). Dried and ground.

6748. Wool Waste. Sweepings from a Philadelphia factory.

6307. Hoof Meal.

6a. Mixture. $\frac{1}{4}$ ground hoof, No. 6307, $\frac{1}{10}$ ammonium sulphate, $\frac{1}{10}$ potassium chlorid and $\frac{2}{3}$ acid phosphate.

6b. Mixture. $\frac{1}{4}$ ground hoof, No. 6307, $\frac{1}{4}$ potassium chlorid and $\frac{2}{3}$ acid phosphate.

4b. Mixture. $\frac{1}{4}$ high-grade dried blood, $\frac{1}{4}$ potassium chlorid and $\frac{2}{3}$ acid phosphate.

4a. Mixture. $\frac{1}{4}$ low-grade dried blood, $\frac{1}{10}$ sodium nitrate, $\frac{1}{10}$ potassium chlorid and $\frac{2}{3}$ acid phosphate.

5b. Mixture. $\frac{1}{4}$ high-grade tankage, $\frac{1}{4}$ potassium chlorid and $\frac{1}{12}$ acid phosphate.

7b. Mixture. $\frac{2}{3}$ raw leather, $\frac{1}{4}$ potassium chlorid and $\frac{2}{3}$ acid phosphate.

5a. Mixture. $\frac{1}{4}$ ground horn (very hard and dry), $\frac{1}{10}$ sodium nitrate, $\frac{1}{10}$ potassium chlorid and $\frac{1}{3}$ acid phosphate.

TABLE I.

Sample Number.	MATERIAL.	PER CENT. OF NITROGEN.				Per cent of avail- ability of total organic nitrogen.
		Total.	Insoluble in pepsin solution.		Insoluble average.	
6311	Bone Sawings.....	4.12	0.28	0.19	0.23	94.4
6176	Steamed Bone.....	2.71	0.62	0.62	0.62	77.1
887	Cotton-seed Meal.....	7.77	1.04	1.07	1.05	86.5
6331	Dried Ground Fish.....	8.74	2.66	2.43	2.54	70.9
6653	Tobacco Dust	1.75	0.51	0.51	0.51	70.9
6602	King Crab.....	9.60	3.05	3.25	3.15	67.2
6749	Wool Waste.....	3.11	2.24	2.13	2.18	29.9
6307	Hoof Meal.....	13.40	6.27	6.52	6.39	52.3
6a	" " in mixture.....	3.24	1.45	1.43	1.44	55.6
6b	" " " "	2.58	1.21	1.22	1.21	53.1
4b	Dried Blood " "	2.92	0.16	0.17	0.16	94.5
4a	" " " "	2.27	0.37	0.39	0.38	83.3
5b	Tankage " "	3.04	0.69	0.69	0.69	77.3
7b	Raw Leather in mixture.....	2.57	2.09	2.04	2.06	19.8
5a	Ground Horn " "	3.09	2.62	2.64	2.63	14.9

The results of these tests confirm on the whole the general belief that the nitrogen of ground bone, blood, cotton-seed meal and high-grade tankage possesses a high degree of availability; they also show that the nitrogen of dried fish, tobacco dust, king crab and hoof meal is considerably less available, while that of wool waste, raw leather and ground horn is shown to be of very inferior quality. It now remains to compare these results with those secured by vegetation tests on similar materials, and see if the same relative degree of availability is maintained. It was impossible, through lack of time, to make special vegetation cultures this year in the materials actually used. The comparison is made, therefore, with the results secured by the Connecticut Station on crops of maize and oats, in 1894 and 1895.* There are no available figures on bone sawings, tobacco

* Rept. Conn. Expt. Station, 1895, p. 112.

dust, king crab or ground horn, and they are therefore not included in the following tabulation. The first column of figures shows the relative availability of the nitrogen based on the Connecticut vegetation experiments. The next column is calculated on the assumption that all of the nitrogen of nitrate of soda is available, although in the experiments referred to, only 68.4 per cent. was actually required for the needs of the plant. The figures of this column are obtained by dividing the figures of the first column by 68.4 and multiplying by 100. The last column of figures represents the relative solubility when dried blood is used as the basis of comparison, and are derived from the figures of Table I, on page 114:

TABLE II.

MATERIAL.	Relative availability by vegetation tests. Per cent.	Same as column one, when nitrate of soda equals 100 per cent.	Relative availability by pepsin digestion, when blood equals 68 per cent.
Nitrate of Soda.....	68.4	100	.....
Cotton-seed Meal.....	49.7	72	62
Dried Blood.....	46.3	68	68
Dried Fish.....	45.0	66	51
Hoof Meal.....	42.5	62	39
Steamed Bone.....	40.9	60	56
Tankage	40.5	59	56
Wool Waste.....	22.1	31	22
Raw Leather.....	1.4	2	14

A comparison of these results shows that, with the exception of raw leather, the pepsin method tends to give lower results than were secured by the vegetation tests. The pepsin results, however, are quite

satisfactory, except in the case of hoof meal, where the pepsin solubility is nearly twenty-three per cent. lower than by the actual culture test. These results therefore confirm the conclusions of other investigators, namely, that "in general, the solubility of the nitrogen of these samples in pepsin solution was a fairly good measure of the relative availability of the nitrogen to the plant under the conditions of the vegetation experiment."* In hoof meal, however, the solubility of the nitrogen in pepsin solution is no indication whatever of its relative availability.

Permanganate of Potash Method.

In seeking for a method that would apply to all classes of ammoniates, the method suggested by Mr. S. H. T. Hayes in Bulletin 47, U. S. Department of Agriculture, page 112, was also tried on four complete fertilizers, the source of whose nitrogen was known, and a few unmixed nitrogenous materials.

METHOD.—Weigh one gram of material into a 500-cc. flask and add 100 cc. of a solution of permanganate of potash. Connect with distilling apparatus and digest for one hour at a very low temperature, gradually increase and distill for one hour longer. Titrate the distilled ammonia in the usual manner. The permanganate solution is made by dissolving 16 grams of potassium permanganate and 200 grams of potassium hydroxid in one liter of water. The same samples were also tested with an acid solution made by dissolving 16 grams of permanganate in one liter of 10 per cent. sulphuric acid. When using this latter method it is also necessary to add 50 cc. of sodium hydrate after the digestion, in order to free the ammonia.

The results obtained by these two methods will be found in the following table:

* Rept. Conn. Expt. Station, 1894, p. 107.

TABLE III.

MATERIAL.	Total Nitrogen. Per cent.	ALKALI SOLUTION.		ACID SOLUTION.	
		Insoluble. Per cent.	Per cent. soluble.	Insoluble. Per cent.	Per cent. soluble.
Dried Blood in mixture.....	2.92	1.08	63.1	1.16	60.3
Tankage "	3.04	1.30	57.2	1.28	57.9
Hoof Meal "	2.58	0.78	69.7	1.19	53.9
Raw Leather "	2.57	1.71	33.5	2.14	17.5
Dried Fish.....	8.74	.....	.....	3.66	58.1
Steamed Bone	2.71	.....	.....	1.55	42.8

By reducing these results to a comparable basis in the same manner as was done in Table II., we obtain the figures given in the table below :

TABLE IV.

	Relative Solubility in Alkali Permanganate.	Relative Solubility in Acid Permanganate.	Relative Availability by Vegetation Tests.
Dried Blood in mixture.....	68	63	68
Tankage "	62	65	59
Hoof Meal "	75	61	62
Raw Leather "	36	20	2
Dried Fish.....	...	65	66
Steamed Bone.....	...	48	60

The results secured both by the acid and alkali digestions are very satisfactory. When digested in alkali solution, hoof meal and raw leather give too high results, while in acid solution all agree closely in comparison with the vegetation tests, except steamed bone, which is too low. These results are too few for any definite conclusions to be drawn from them, but those secured by the acid digestion are very encouraging, and this method, possibly with some modifications, promises at least a partial solution of the problem of a laboratory method for determining the availability of organic nitrogen.

The Volumetric Estimation of Phosphoric Acid.

In recent years the great increase in the number of fertilizers sent to the Station for analysis has made it advisable and almost imperative to adopt such methods of analysis as would be time-saving without any loss in accuracy. In 1895, in Bulletin 46, U. S. Department of Agriculture, page 13, a volumetric method for the estimation of phosphoric acid was proposed by Mr. B. W. Kilgore, of North Carolina, which seemed to possess the desired elements of quickness and accuracy. During the past season this method has been used at this Station in making check determinations against the official gravimetric method. It was found necessary to introduce a few modifications on the original method, and the method thus modified is here printed for future reference.

Method.

Weigh 2 grams of material into a porcelain crucible, evaporate with 3 cc. of magnesium nitrate, ignite and dissolve in hydrochloric acid. To an aliquot part of this solution (0.25 gram) add 5 cc. of concentrated nitric acid, neutralize with ammonia and clear with a few drops of nitric acid. Heat on the water bath to 60-65 degrees C., add 50 cc. of freshly-filtered molybdic solution for each decigram of phosphorus anhydride present, and digest at the same temperature for 15 to 20 minutes.

Decant the clear liquid on a filter as quickly as possible (a plain filter without suction). Wash the precipitate by decantation twice with the nitric acid solution, once with the potassium or ammonium nitrate solution, and transfer it to the filter and wash with 150 cc. of cold water. Wash the precipitate with the filter into the beaker, add an excess of the standard potassium hydroxid solution and a few drops of the phenolphthalein solution, and titrate the excess of alkali by adding the standard nitric acid solution until the color disappears. The number of cubic centimeters of alkali used, less the number of cubic centimeters of acid necessary to neutralize the solution, is equal to the number of milligrams of phosphorus anhydride present.

REAGENTS.—The reagents used were in all cases exactly the same as described in Bulletin 46, U. S. Department of Agriculture, pp. 13, 14.

The chief differences between Kilgore's original method and this modification lie in the preparation of the solution, the time of heating with molybdic solution, and the amount of water used in washing the ammonic phosphomolybdate precipitate. It was found that solution in nitro-hydrochloric acid in the case of some refractory materials containing a large amount of organic matter, sometimes gave unsatisfactory results, by failure to secure a complete solution of

the phosphates present. The old method of adding magnesium nitrate, igniting and dissolving in hydrochloric acid was therefore employed, and with perfect satisfaction. The time of heating, viz., six minutes, advised in the original method, was found to be inadequate in many cases, especially when low percentages of phosphoric acid were present. The time therefore was changed to 15 minutes for high-grade and 20 minutes for low-grade materials. After repeated careful and delicate qualitative tests it was found that the yellow precipitate was practically free of acidity after 100–150 cc. of water had been passed through it. The well-known slight solubility of this precipitate in water would seem to argue for the use of as little water as possible, and having found 100–150 cc. to be quite sufficient, that amount was employed in all our work. Another point, trifling in itself and yet perhaps productive of inaccuracy when disregarded, is the time of addition of the indicator. In our first trials of this method the phenolphthalein was added direct to the beaker containing the yellow precipitate before titration was commenced. This practice was found to cause much trouble in getting a clear final reaction on account of the formation of certain of the characteristic blue and violet molybdenum colors. In later experiments it was found that this difficulty was entirely obviated if the phenol was not added until the precipitate had been entirely dissolved in the standard alkali solution, and then only a small quantity, one or two drops.

As stated above, this modified method was used this year in comparison with the official gravimetric method. The materials analysed included 276 complete fertilizers, of varying composition and origin, and are believed to fairly represent the average goods on the market at the present time. The results secured were extremely satisfactory, the average results by the volumetric method being 10.72 per cent. against 10.70 per cent. by the official method. Of these results, 150 were higher by the volumetric, 113 lower and 13 identical with the official method; the greatest variation was 0.16 per cent., and 114 samples varied less than 0.05 per cent.

The individual analyses are shown in the following table:

Comparative Results on Total Phosphoric Acid.

Official.	Volumetric.	Official.	Volumetric.	Official.	Volumetric.	Official.	Volumetric.	Official.	Volumetric.	Official.	Volumetric.	Official.	Volumetric.	Official.	Volumetric.	Official.	Volumetric.
P. c.	P. c.	P. c.	P. c.	P. c.	P. c.	P. c.	P. c.	P. c.	P. c.	P. c.	P. c.	P. c.	P. c.	P. c.	P. c.	P. c.	P. c.
11.69	11.77	11.88	11.90	9.65	9.68	8.10	8.20	9.69	9.79	8.29	8.42	12.21	12.24	10.18	10.08	10.08	10.08
11.97	12.04	12.06	12.08	9.61	9.48	7.00	7.00	12.88	12.80	7.90	8.00	14.68	14.68	9.26	9.20	9.20	9.20
9.68	9.58	9.02	8.94	12.73	12.60	11.51	11.44	9.84	9.48	10.22	10.26	13.08	13.01	9.86	9.76	9.76	9.76
9.61	9.58	11.52	11.62	11.82	11.69	-9.54	9.58	11.30	11.24	8.97	8.97	13.67	13.61	10.00	9.96	9.96	9.96
10.13	10.11	10.72	10.88	16.40	16.50	10.26	10.24	6.71	6.62	11.50	11.42	10.58	10.68	8.32	8.37	8.37	8.37
10.51	10.49	11.90	11.80	10.81	10.75	16.58	16.55	9.71	9.77	8.98	9.00	9.09	9.12	8.36	8.38	8.38	8.38
10.49	10.53	13.67	13.62	11.79	11.75	13.08	13.07	8.20	8.20	10.26	10.31	11.58	11.46	11.60	11.51	11.51	11.51
10.68	10.80	12.87	12.80	11.43	11.49	10.23	10.14	11.76	11.89	12.53	12.51	11.90	11.86	10.38	10.38	10.38	10.38
11.13	11.20	11.00	11.06	11.78	11.92	12.80	12.18	11.71	11.74	9.13	9.10	9.80	9.87	12.65	12.62	12.62	12.62
12.06	12.13	9.76	9.76	8.66	8.70	12.82	12.90	10.53	10.66	14.15	14.10	11.06	11.11	10.52	10.54	10.54	10.54
12.69	12.69	12.18	12.24	12.73	12.69	13.49	13.42	8.73	8.78	9.68	9.67	11.87	11.80	9.30	9.28	9.28	9.28
11.96	12.09	12.00	12.70	9.86	9.74	14.56	14.62	7.50	7.62	9.83	9.86	10.36	10.28	10.56	10.48	10.48	10.48
9.84	9.87	9.45	9.83	6.10	6.06	11.94	11.93	11.68	11.78	8.32	8.30	11.13	11.11	7.46	7.60	7.60	7.60
6.76	6.74	9.88	9.88	12.28	12.21	13.81	13.00	9.83	9.94	9.87	9.86	10.77	10.68	11.46	11.39	11.39	11.39
9.43	9.43	13.70	13.60	8.60	8.70	13.29	13.84	8.00	7.93	11.47	11.44	8.77	8.68	9.12	9.24	9.24	9.24
10.00	10.12	13.22	13.15	10.47	10.40	13.02	13.13	10.49	10.51	10.09	10.04	11.38	11.34	8.50	8.37	8.37	8.37
11.67	11.55	11.19	11.12	10.76	10.61	11.57	11.60	12.77	12.87	11.07	11.12	9.79	9.86	11.38	11.38	11.38	11.38
11.81	11.83	13.73	13.66	12.15	12.01	11.74	11.78	7.30	7.36	10.64	10.72	11.50	11.44	11.06	10.99	10.99	10.99

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Comparative Results on Total Phosphoric Acid—Continued.

Oficial.	Volúmetría.	Oficial.	Volúmetría.	Oficial.	Volúmetría.	Oficial.	Volúmetría.	Oficial.	Volúmetría.	Oficial.	Volúmetría.	Oficial.	Volúmetría.	Oficial.	Volúmetría.
p. c.	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.
9.02	9.06	12.26	7.26	11.06	11.04	11.66	11.60	7.67	8.63	9.86	9.86	9.86	9.86	9.86	9.86
12.45	12.42	9.81	6.84	6.88	11.92	11.82	11.86	8.06	6.24	8.91	8.91	8.91	8.91	8.91	8.91
12.48	12.84	11.81	7.86	8.88	8.99	12.15	12.26	12.45	11.17	9.80	9.80	9.80	9.80	9.80	9.80
12.11	12.08	10.80	11.17	10.20	10.07	8.67	8.58	14.45	10.82	10.85	10.85	10.85	10.85	10.85	10.85
8.14	8.26	12.07	12.46	9.97	10.06	12.87	12.90	13.64	8.76	11.27	11.27	11.27	11.27	11.27	11.27
9.76	9.82	13.62	11.87	11.84	11.88	11.68	11.74	10.81	10.90	9.86	9.86	9.86	9.86	9.86	9.86
9.92	10.00	14.47	13.27	13.84	12.09	8.86	8.46	9.86	10.98	12.29	12.29	12.29	12.29	12.29	12.29
10.59	10.66	11.46	13.07	12.86	10.66	8.69	8.71	10.82	10.45	9.86	9.86	9.86	9.86	9.86	9.86
11.71	11.72	12.88	11.51	11.64	11.46	9.88	9.96	12.63	9.87	12.16	12.16	12.16	12.16	12.16	12.16
8.49	8.62	9.08	12.66	12.64	9.81	9.91	9.94	13.45	7.60	11.19	11.19	11.19	11.19	11.19	11.19
8.72	8.83	11.87	11.58	11.46	8.64	11.45	11.44	9.06	9.66	9.74	9.74	9.74	9.74	9.74	9.74
9.15	9.17	9.66	5.90	5.91	10.18	9.12	9.28	11.28	13.14	11.20	11.20	11.20	11.20	11.20	11.20
8.74	8.83	11.74	6.95	7.07	8.78	13.96	13.95	13.67	13.14	10.87	10.87	10.87	10.87	10.87	10.87
11.87	11.96	10.17	12.21	12.16	9.78	11.29	11.38	10.81	7.12	11.49	11.49	11.49	11.49	11.49	11.49
11.66	11.40	11.70	10.65	10.66	11.89	13.47	13.46	14.67	9.27	9.82	9.82	9.82	9.82	9.82	9.82
8.96	9.01	10.22	11.00	11.04	11.86	10.92	10.87	12.69	11.66	11.68	11.68	11.68	11.68	11.68	11.68
14.87	14.26	9.84	10.77	10.88	8.69	9.69	9.69	10.06	8.96	9.06	9.06	9.06	9.06	9.06	9.06

FODDERS AND FEEDS

I.

ANALYSES.

The larger number of analyses reported this year were made as a part of other investigations. A few were examined to determine their purity, and one or two are products new to this State. The cow peas, represented by Nos. 1056 and 1057, were grown for the purpose of testing the comparative usefulness of the two varieties as green manures, and indirectly to determine the amount of animal food produced per acre by these crops. They are beginning to be used as soiling crops, and but few data concerning their chemical composition are yet available. The samples of green rye, rape, etc., were examined in connection with experiments that were reported in 1895.

Sample No. 1072 was suspected of containing deleterious foreign matter; the analysis shows it to be a good representative product, and no foreign or deleterious substance could be detected.

Sample No. 1058, "Dried Distillery Grains," is a comparatively new feed, and is now largely exported. It contains nearly twice as much ether extract, about the same amount of protein and considerably more fiber than gluten feed, the refuse product from glucose factories, which is largely used and is highly regarded by farmers; its content of fiber, and consequently more bulky character, should make this an excellent product for use with ordinary farm crops poor in protein and ether extract.

Sample No. 1060, represents a product which possessed such a fine mechanical condition as to create a suspicion that it was not genuine. The analysis shows it to be really richer in protein and quite as rich in ether extract as the average sample of "Dried Brewers' Grains."

Sample No. 1053 is claimed by the manufacturers to be improved by the addition of the mineral matters usually extracted in the process by which gluten feed is obtained.* That the purpose has been accom-

* Bulletin No. 105, New Jersey Experiment Station.

plished is shown by the content of fertilizer constituents contained in it, and also that it has been gained without decreasing the content of ether extract and protein, the chief substances in this class of feeds. See average analysis, pages 128-131.

Sample No. 1073, "Oat Feed," is the refuse from oatmeal works, and at the price per ton, \$13.50, is a more expensive product than wheat bran would be at the same price per ton, since it is shown to be poorer in ether extract and protein and richer in fiber than average wheat bran.

Sample No. 1071, "Nutritone," is a condimental food, which costs, according to the amount purchased, from \$250 to \$300 per ton. So far as food constituents are concerned, it is but little richer than wheat middlings, with which it compares very favorably in its content of ether extract; its high content of ash indicates that mineral matters rich in phosphoric acid and potash have been added. The circular accompanying this feed claims that its use will result in an increased quantity and an improved quality of milk. The conclusions reached by the experiments conducted at the Vermont Experiment Station to test this point,* are "that the material did not have a tendency to increase production over and above an equivalent amount of nutriment derived from linseed meal." No attempt was made to examine the claimed tonic qualities of this product.

Sample No. 1068, "Apples," was analysed because entering into a ration which was being studied in connection with a test for dairy cows. The dry matter contained is quite as great as that in the average green forage, though consisting almost entirely of nitrogen free extract. Where apples are abundant they would serve an excellent purpose when used in moderate quantities.

*Annual Report Vermont Experiment Station, 1894.

ANALYSES OF

Station Number.	SAMPLE OF	SOURCE.	SAMPLED BY
1055	Crimson Clover, Green.....	College Farm, May 17th, 1895.	Station.
1056	Cow Pea Vine, Black.....	S. T. Dowler, Vineland, N. J.	S. T. Dowler, Vineland.
1057	" " " Unknown.....	" " " "	" " "
1054	Eye, Green.....	Rotation Expt., College Farm.	Station.
1059	Rape, Tops.....	E. E. Horton, Chester, N. J.	E. E. Horton, Chester.
1066	Corn Silage.....	Frank Roe, Augusta, N. J.	Station.
1067	Hay.....	" " " "	"
1061	Wheat Bran.....	" " " "	"
1072	" Middlings.....	Wills A. Seward, Budds Lake, N. J.	Wills A. Seward, Budds Lake.
1058	Dried Distillery Grains.....	Greenpoint Distillery, L. I.	H. Mettler, Millstone.
1080	Dried Brewers' Grains.....	Page & Co., St. Louis, Mo.	T. S. Gibbs, Columbus.
1062	" " "	Frank Roe, Augusta, N. J.	Station.
1063	Linseed Meal	" " " "	"
1053	Improved Buffalo Gluten Feed	American Glucose Co., Peoria, Ill.	Manufacturer.
1065	Chicago Gluten Meal.....	Frank Roe, Augusta, N. J.	Station.
1064	Hominy Meal	" " " "	"
1073	Oat Feed	— — — — —	S. J. Du Bois, Daretown.
1071	Nutritone	Frank Roe, Augusta, N. J.	Station.
1068	Apples.....	" " " "	"

FODDERS AND FEEDS.

Station Number.	SAMPLE OF	POUNDS PER HUNDRED OF									
		Water.	Riber Extract.	Fiber.	Protein.	Ash.	Nitrogen-Free Extract.	Albuminoids.	Nitrogen.	Phosphoric Acid.	Potash.
1055	Crimson Clover, Green.....	85.86	0.47	2.90	2.00	1.51	7.07	2.06	0.48	0.16	0.00
1056	Cow Pea Vine, Black.....	71.82	1.08	5.87	4.24	1.61	16.28	3.88	0.68	0.22	0.29
1057	" " " Unknown.....	79.09	0.98	3.91	2.78	1.90	10.79	1.94	0.45	0.09	0.24
1054	Rye, Green.....	77.68	0.64	6.26	2.55	1.84	11.58	1.09	0.41	0.26	0.07
1059	Rape, Tops.....	84.86	0.80	1.20	2.55	1.62	9.27	1.75	0.41	0.15	0.37
1068	Corn Silage.....	72.23	0.78	6.22	2.46	1.08	17.28	1.68	0.89	0.14	0.06
1067	Hay.....	7.12	2.78	30.77	7.48	4.26	47.65	5.81	1.20	0.88	1.42
1061	Wheat Bran.....	12.80	5.04	8.80	16.28	5.81	81.77	18.06	3.61	2.26	1.56
1072	" Middlings.....	8.87	6.80	7.86	19.44	5.09	58.44	15.56	3.11	2.89	2.89
1068	Dried Distillery Grains.....	4.96	22.16	18.67	24.86	1.12	88.28	28.89	3.98	0.87	0.12
1060	" Brewers' Grains.....	8.25	7.62	12.16	81.85	2.94	37.45	80.94	5.10	0.91	0.05
1062	" " ".....	9.62	7.58	12.67	26.78	3.86	40.09	25.50	4.28	0.95	0.05
1068	Linseed Meal.....	10.57	6.49	6.45	36.06	4.62	85.81	80.94	6.77	1.09	1.19
1068	Improved Buffalo Gluten Feed.	8.88	11.98	5.11	24.67	3.14	46.77	20.68	3.95	1.26	0.64
1065	Chicago Gluten Meal.....	11.64	7.07	2.71	36.09	1.18	40.76	85.69	5.87	0.54	0.06
1064	Hominy Meal.....	9.74	9.68	3.87	11.76	2.80	62.80	10.81	1.88	1.41	0.74
1078	Oat Feed.....	6.59	3.74	20.45	9.76	5.64	58.82	9.56	1.56	0.73	0.68
1071	Nutrietone.....	8.07	6.49	6.06	21.29	19.68	88.41	18.84	3.41	8.19	3.06
1068	Apples.....	84.27	0.76	1.19	0.64	0.80	12.88	0.64	0.10	0.02	0.14

II.

MARKET PRICES OF COMMERCIAL FEEDS.

The gathering of statistics concerning the average market prices of commercial feeds used in the State, begun in 1891, has been continued, though owing to the necessity of preparing the report of 1895 previous to January 1st, the table of averages given does not include the average data for 1896. The value of a permanent record of such a character is so obvious that it is continued, even though the late publication robs it of its present usefulness.

KINDS OF FEED.	1895.		1896.	AVERAGE FOR THE SIX MONTHS PRECEDING JANUARY 1.				
	Aug. 1.	Nov. 1.	Jan. 1.	1895-96.	1894-95.	1893-94.	1892-93.	1891-92.
Corn Meal, or Cracked Corn..	\$22.76	\$18.24	\$15.51	\$18.84	\$23.99	\$20.49	\$21.65	\$25.88
“ and Cob Meal.....	18.92	15.28	18.69	15.95	17.88	21.00	.....	.....
Ground Oats.....	24.76	19.92	18.17	20.92	28.47	27.68	30.17	24.25
Ground Corn and Oats, equal parts.....	22.88	19.00	16.68	19.49	25.54	23.90	25.12	27.07
Gluten Meal.....	20.14	18.42	17.48	18.66	22.00	24.83	27.00	22.50
Buffalo Gluten Feed.....	18.00	17.00	14.00	16.83	20.00	20.17	20.00	.....
Chicago Feed.....	17.67	15.67	14.67	16.00	17.17	18.67	17.67	.....
Corn Bran.....	15.88	13.88	12.50	12.72	15.17	16.92	15.88	18.00
Hominy Meal.....	19.00	16.50	14.75	16.75	21.88	18.88	19.89	23.00
“ Chops.....	18.67	16.50	14.67	16.61	20.61	18.88	20.00	23.50
Wheat Bran.....	18.00	16.25	15.11	16.45	18.49	18.48	18.11	21.06
“ Middlings, White.....	21.90	19.00	17.81	19.67	21.85	21.19	21.08	25.50
“ “ Brown.....	18.67	17.08	15.75	17.17	19.47	18.88	18.65	22.75
“ Shorts.....	20.00	19.00	17.75	18.92	22.17	19.88	18.88	26.00
Ship Stuff.....	18.00	16.75	15.75	16.88	18.00	17.58	17.67	27.50
Rye Bran.....	19.88	18.00	15.67	17.67	18.50	19.50	18.50	19.50
“ Middlings.....	20.00	19.00	17.50	18.88	20.44	20.88	20.07	24.00
Buckwheat Bran.....	16.00	12.50	12.00	18.50	18.80	11.00	11.00	12.00
“ Middlings.....	18.00	15.50	14.75	16.08	18.40	19.00	17.50	19.00
Cotton-Seed Meal.....	21.00	21.68	22.95	21.86	23.27	27.49	27.75	28.00
Linseed Meal, Old Process...	23.50	21.75	22.71	22.65	27.12	30.23	28.61	30.95
“ “ New Process...	18.00	17.00	17.00	17.88	21.17	.....	.....	.....
Malt Sprouts.....	16.00	15.00	14.88	15.18	16.72	17.17	18.08	17.67
Dried Brewers' Grains.....	16.70	15.70	15.10	15.88	18.27	18.61	19.75	19.88
Pea Meal.....	.....	.....	.....	.....	18.50	.....	.....	.....

With the exception of cotton-seed meal, all of the feeds quoted are lower January 1st, 1896, than on August 1st, 1895, and in all cases the market prices for 1895 are lower than for 1894; this, of course, affects the farmer in two directions, first, in the produce he has to sell, and second, in that which he has to buy; and the lowering of prices changes somewhat the situation existing in 1894 in reference to the exchange of farm products for concentrated feeds. For instance, the prices for corn and oat feeds, those which many have to sell, which under previous conditions it was economy to sell, because rich in carbohydrates, were 21 per cent. lower for the year 1895 than for 1894, while those particularly rich in ether extract and protein, as gluten meal, Buffalo gluten feed, wheat bran, cotton-seed meal, dried brewers' grains, malt sprouts, which many have to buy, and which they should buy in order to profitably use their coarse products, were 17 per cent. lower, that is, the conditions now are such that the class of nutrients, carbohydrates, are relatively lower in price than in 1894, and hence because the cost of the nutrients, ether extract and protein, have not been reduced in the same proportion, the losses due to the feeding of rations unbalanced in the sense that they were too rich in carbohydrates, would be much less than they were in 1894. This is not an argument, however, for a continuation of wasteful methods of feeding, but rather that greater care should be exercised in the selection of those concentrated feeds necessary to properly balance the carbohydrates and greater care in selling the home-grown produce.

III.

AVERAGE COMPOSITION OF FODDERS AND FEEDS.

The very large increase in the number of analyses of fodders and feeds, in recent years, has contributed much to our knowledge of their composition; these increased data make it necessary to revise such averages as have been published in our reports in the past, and which were derived largely from our own analyses. The averages in the following tables have been largely taken from the compilations made by Dr. E. H. Jenkins and Mr. A. L. Winton, and reported in Bulletin No. 11 of the Office of Experiment Stations. In many cases the analyses made at this Station since that report was issued, particularly of the commercial feeds, have been included in the averages. The average analysis of corn stalks, as derived from the analyses made at this Station, is also included, since it represents more nearly the composition of the stalks as fed in this State.

Number of Analyses.	KIND OF FEEDING STUFF.	PERCENTAGE COMPOSITION.					
		Water.	Ether Extract	Fiber.	Protein.	Ash.	Nitrogen-Free Extract.
GREEN FODDERS AND SILAGE.							
17	Pasture Grass.....	70.8	1.2	5.5	4.7	2.8	14.5
4	Orchard Grass, in bloom	78.0	0.9	8.2	2.6	2.0	12.3
56	Timothy.....	61.6	1.2	11.8	3.1	2.1	20.2
Corn (Maize) Fodder :							
40	Flint varieties.....	79.8	0.7	4.8	2.0	1.1	12.1
68	Dent varieties.....	79.0	0.5	5.6	1.7	1.2	12.0
21	Sweet varieties.....	79.1	0.5	4.4	1.9	1.3	12.3
48	Red Clover.....	70.8	1.1	8.1	4.4	2.1	12.5
4	Alsike Clover, in bloom.....	74.8	0.9	7.4	3.9	2.0	11.0
28	Alfalfa (Lucern).....	71.8	1.0	7.4	4.8	2.7	12.3
2	Crimson Clover (just heading).....	89.2	0.4	1.8	2.5	1.2	4.9
7	“ “ (full bloom).....	82.0	0.6	4.8	3.1	1.5	8.0
11	Cow Pea.....	83.5	0.4	4.7	2.5	1.7	7.2
11	Borghum (whole plant).....	79.4	0.5	6.1	1.3	1.1	11.6
8	Rye Fodder.....	76.7	0.6	10.9	2.6	1.8	7.4
5	Oat Fodder.....	62.2	1.4	11.2	3.4	2.5	19.3
100	Corn (Maize) Silage.....	79.0	0.8	6.0	1.7	1.4	11.0
HAY AND DRY COARSE FODDERS.							
35	Corn (Maize) Fodder.....	42.2	1.6	14.8	4.5	2.7	34.7
15	“ “ Stalks.....	68.4	0.5	11.0	1.9	1.2	17.0
7	“ “ Stalks*.....	10.2	1.2	28.2	4.6	5.3	50.6
11	Hay, Mixed Meadow Grasses.....	16.0	2.1	29.9	6.4	4.6	41.0
70	Timothy Hay.....	13.6	2.5	23.9	5.9	4.4	44.7
12	Hay, Hungarian Grass.....	7.7	2.1	27.7	7.5	6.0	49.0
38	Red Clover Hay.....	15.8	3.3	24.8	12.3	6.2	38.1
9	Alsike Hay.....	9.7	2.9	25.6	12.3	8.3	40.7
21	Alfalfa (Lucern) Hay.....	8.4	2.7	25.0	14.3	7.4	42.7
7	Wheat Straw.....	9.6	1.3	33.1	3.4	4.2	43.4
7	Rye Straw.....	7.1	1.2	33.9	3.0	3.2	46.6
12	Oat Straw.....	9.2	2.3	37.0	4.0	5.1	42.4
ROOTS AND TUBERS.							
10	Mangels.....	90.9	0.2	0.9	1.4	1.1	5.5
4	Rutabagas.....	88.6	0.2	1.3	1.2	1.2	7.5
3	Turnips.....	90.5	0.2	1.2	1.1	0.8	6.2
9	Red Beets.....	88.5	0.1	0.9	1.5	1.0	8.0
19	Sugar Beets.....	86.5	0.1	0.9	1.3	0.9	9.3
8	Carrots.....	83.6	0.4	1.3	1.1	1.0	7.6
58	Potatoes.....	79.1	0.1	0.4	2.1	0.9	17.4
20	Sweet Potatoes.....	72.4	0.3	0.9	1.1	1.3	24.0

* New Jersey samples.

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PER CENT. OF DIGESTIBLE			Nutritive Ratio. 1:	PER CENT. OF FERTILIZER CONSTITUENTS.		
Fat.	Protein.	Carbohydrates.		Nitrogen.	Phosphoric Acid.	Potash.
0.8	8.5	16.2	5.2	0.75	0.19	0.60
0.6	1.8	15.5	9.4	0.41	0.22	1.29
0.6	2.0	21.1	11.8	0.50	0.80	0.88
0.5	1.5	11.2	8.8	0.82	0.15	0.88
0.4	1.2	12.1	10.9	0.27	0.15	0.88
0.4	1.4	11.7	9.1	0.80	0.15	0.88
0.7	2.9	18.8	5.2	0.70	0.19	0.67
0.6	2.6	11.8	4.9	0.68	0.15	0.28
0.6	8.2	12.2	4.8	0.77	0.15	0.64
0.2	1.7	4.4	2.9	0.40	0.12	0.84
0.8	2.2	8.2	4.1	0.50	0.18	0.89
0.1	1.7	7.2	4.4	0.40	0.08	0.24
0.4	0.8	12.7	17.1	0.21	0.10	0.27
0.5	2.1	14.0	7.8	0.41	0.11	0.87
1.0	2.7	22.4	9.2	0.54	0.18	0.88
0.6	1.2	11.8	11.1	0.27	0.11	0.87
1.2	8.8	38.5	11.1	0.72	0.84	0.56
0.4	1.4	19.8	14.5	0.80	0.08	0.85
0.9	8.4	54.2	16.6	0.78	0.28	0.99
1.0	8.6	42.9	12.6	1.02	0.26	1.48
1.2	8.8	44.6	14.4	0.94	0.88	1.42
1.0	4.2	46.7	11.4	1.20	0.85	1.80
2.0	7.7	89.2	5.7	1.98	0.86	2.10
1.7	8.1	41.4	5.6	2.05	0.67	2.28
0.9	11.0	87.8	8.7	2.29	0.50	1.65
0.4	0.8	87.2	47.8	0.50	0.09	0.72
0.4	0.8	88.6	49.5	0.48	0.29	0.79
0.7	1.5	40.4	28.1	0.64	0.22	1.21
.....	1.1	4.8	4.4	0.22	0.06	0.29
.....	0.9	7.1	7.9	0.19	0.12	0.49
.....	0.6	5.5	9.2	0.18	0.10	0.89
.....	0.9	7.6	8.4	0.24	0.09	0.44
.....	1.1	9.8	8.5	0.29	0.10	0.48
.....	1.0	7.1	7.1	0.18	0.09	0.51
.....	1.4	16.1	11.5	0.84	0.12	0.45
.....	0.7	22.4	82.0	0.18	0.10	0.51

Number of Analyses.	KIND OF FEEDING STUFF.	PERCENTAGE COMPOSITION.					
		Water.	Ether Extract.	Fiber.	Protein.	Ash.	Nitrogen-Free Extract.
	GRAINS AND OTHER SEEDS.						
	Corn (Maize):						
68	Flint.....	11.8	5.0	1.7	10.5	1.4	70.1
86	Dent.....	10.6	5.0	2.3	10.3	1.5	70.4
26	Sweet.....	8.8	8.1	2.8	11.6	1.9	66.8
282	Wheat, Winter Varieties.....	10.5	2.1	1.8	11.8	1.8	72.0
6	Eye.....	11.6	1.7	1.7	10.6	1.9	72.5
30	Oats.....	11.0	5.0	9.5	11.8	8.0	69.7
8	Buckwheat.....	12.6	2.2	8.7	10.0	2.0	64.5
	MILL PRODUCTS AND REFUSE FEEDS.						
95	Corn (Maize) Meal.....	14.4	3.8	1.9	9.3	1.4	66.2
7	" and Cob Meal.....	15.1	3.5	6.6	8.5	1.5	64.8
2	" Bran.....	8.5	8.1	11.5	11.4	0.8	69.7
101	Wheat Bran, all analyses.....	11.7	4.1	8.9	15.4	5.9	54.0
13	" Shorts.....	11.7	4.5	7.0	15.1	4.4	57.3
41	" Middlings.....	11.8	4.0	4.4	15.7	3.2	60.9
10	" Screenings.....	11.6	3.0	4.9	12.6	2.9	65.1
9	Rye Bran.....	11.6	2.8	8.4	14.4	3.5	64.3
1	" Shorts.....	9.8	2.8	5.1	13.0	4.9	59.9
3	Buckwheat Bran.....	12.9	5.9	13.4	22.1	4.3	41.4
7	" Middlings.....	12.8	7.5	3.8	23.0	5.0	42.9
5	Rice Bran.....	9.7	8.8	9.5	12.1	10.0	49.9
8	Malt Sprouts.....	9.3	1.9	10.6	25.9	6.5	45.3
21	Brewers' Grains.....	75.7	1.7	3.7	5.9	0.9	12.1
28	" " Dried.....	8.7	6.7	13.0	23.3	3.7	44.6
6	Gluten Meal.....	8.0	14.6	1.6	33.0	1.3	41.5
7	Chicago Gluten Meal.....	9.5	5.7	1.5	34.1	0.9	43.1
9	Buffalo Gluten Feed.....	8.8	12.7	6.7	21.5	0.9	49.9
3	Grano Gluten Feed.....	6.0	14.2	11.4	31.0	2.7	34.7
3	Cerealine Feed.....	9.6	8.1	6.8	10.6	2.6	63.3
5	Hominy Chop.....	8.9	9.7	3.5	11.4	2.9	63.6
3	Corn Oil Meal.....	9.0	13.5	6.7	24.3	2.4	43.6
47	Cotton-Seed Meal.....	8.0	12.6	5.6	42.4	7.2	24.2
29	Linseed Meal, old process.....	9.2	7.7	3.3	33.6	5.7	35.5
14	" " new process.....	10.1	3.0	9.5	33.2	5.8	33.4

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PER CENT. OF DIGESTIBLE			Nutritive Ratio. 1:	PER CENT. OF FERTILIZER CONSTITUENTS.		
Fat.	Protein.	Carbohydrates.		Nitrogen.	Phosphoric Acid.	Potash.
3.8	8.9	66.5	8.5	1.68	0.70	0.40
3.6	8.8	66.2	8.6	1.65	0.70	0.40
6.2	9.9	63.7	8.0	1.82	0.72	0.41
1.8	9.2	55.9	6.6	1.89	0.93	0.64
1.2	8.3	65.5	8.3	1.70	0.85	0.56
4.1	8.7	45.6	6.4	1.89	0.89	0.67
1.8	7.7	49.2	7.0	1.60	0.45	0.21
2.9	7.9	65.7	9.2	1.49	0.61	0.33
2.9	6.5	56.3	9.8	1.36	0.44	0.53
6.6	9.7	53.3	7.2	1.82	0.19	0.07
3.3	13.6	45.0	3.9	2.45	2.88	1.63
3.2	11.6	45.4	4.6	2.42	1.38	0.65
2.9	12.2	47.2	4.5	2.51	1.41	0.70
2.2	9.8	51.0	5.3	2.00		
1.6	9.5	43.2	5.5	2.30	1.60	0.96
1.6	11.9	45.1	4.1	2.88	2.19	1.21
3.4	13.3	28.6	2.4	3.54	1.70	1.14
5.4	22.4	32.7	2.1	4.48	2.21	1.15
5.1	3.0	36.9	6.2	1.98	1.98	0.82
1.5	20.7	45.8	2.4	4.14	1.63	1.85
1.4	4.3	9.2	3.0	0.94	0.31	0.05
5.5	16.8	34.0	2.9	3.72	1.06	0.08
12.3	23.7	33.5	2.5	5.25	0.56	0.07
5.0	29.7	44.6	2.0	5.57	0.33	0.05
10.3	13.3	43.1	3.3	3.44	0.33	0.07
11.5	26.4	33.0	2.3	4.96	0.66	0.20
6.6	9.0	58.4	7.8	1.69	1.25	0.67
7.9	9.6	53.3	7.6	1.82	1.47	0.73
10.9	21.1	33.2	3.1	3.96	1.45	0.17
11.4	36.0	22.3	1.4	6.79	3.06	1.89
7.0	29.3	34.5	1.8	5.37	1.92	1.40
2.7	27.2	31.3	1.4	5.31	1.78	1.36

The tables also show the average amounts of the digestible constituents in each feed, as derived from the best data available, and the "nutritive ratio" derived by multiplying the digestible fat by two and one-half, thus converting it into terms of carbohydrates, adding this amount to the digestible carbohydrates, and dividing by the percentage of digestible protein.

Although the per cent. of the fertilizer constituents, nitrogen, phosphoric acid and potash, accompanies each food analysis, another table is constructed (page 133), in which is shown the amounts of these constituents contained in a ton of the principal farm crops and commercial feeds. The content of fertilizing elements, particularly the mineral constituents, has no special reference to the usefulness of any product as a feed, but rather to the character and composition of the manure derived from feeding it; to the loss in fertility that follows the sale of farm produce, and the loss or gain that follows the exchange of farm produce for commercial feeds. This matter has already been referred to in preceding pages; it is of great importance, and should be carefully studied by all farmers.

KIND OF FEED.	CONTAINED IN 2,000 POUNDS.		
	Nitrogen.	Phosphoric Acid.	Potash.
	lbs.	lbs.	lbs.
Corn Fodder.....	14.4	6.8	11.2
" Stalks (New Jersey).....	14.6	4.6	19.8
Timothy Hay.....	18.4	6.6	28.4
Red Clover Hay.....	39.6	7.2	42.0
Scarlet Clover Hay.....	55.8	18.9	44.2
Alsike Clover Hay.....	41.0	18.4	44.6
Wheat Straw.....	10.0	1.8	14.4
Rye Straw.....	9.6	5.8	15.8
Oat Straw.....	12.8	4.4	24.2
Corn Kernels, Flint.....	32.6	14.0	8.0
" " Dent.....	32.0	14.0	8.0
Winter Wheat.....	37.8	18.6	12.8
Rye.....	34.0	17.0	11.2
Oats.....	37.8	17.8	12.4
Buckwheat.....	32.0	9.0	4.2
Wheat Bran.....	49.2	57.6	32.6
" Middlings.....	50.2	28.2	14.0
Rye Bran.....	46.0	32.0	19.2
Corn Bran.....	36.4	3.8	1.4
Buckwheat Bran.....	70.8	34.0	22.8
" Middlings.....	89.6	44.2	28.0
Malt Sprouts.....	82.8	32.6	37.0
Brewers' Grains.....	18.8	6.2	1.0
" " Dried.....	74.4	21.2	1.6
Gluten Meal.....	105.0	11.2	1.4
Chicago Gluten Meal.....	111.4	6.6	1.0
Buffalo Gluten Feed.....	68.8	7.6	1.4
Cerealine Feed.....	33.8	25.0	18.4
Hominy Chop.....	36.4	29.4	14.6
Corn Oil Meal.....	79.2	29.0	8.4
Cotton-Seed Meal.....	125.4	61.6	38.0
Linseed Meal, old process.....	107.4	33.4	28.0
" " new process.....	106.2	35.6	27.2

THE COST AND COMPOSITION OF MILK IN CITIES IN NEW JERSEY.

The purpose of this investigation was to obtain definite information concerning the retail price of milk to consumers, the variations in its composition and food value, and the relative cost of the nutrients furnished by the different samples.

Sampling.

The samples represented as nearly as possible the actual supply of the four cities from which they were secured, viz., New Brunswick, Newark, Trenton and Camden, that is, while the samples were not taken from every dealer, the number taken represents a fair proportion of both small and large producers and dealers. The samples were in all cases taken in the morning from the delivery wagons on their route and from the stores of retailers, and therefore represent milk as delivered to consumers; they were taken in some cases from full cans, in other cases from cans partially full, in others from cans almost empty, and in still others from bottles; in the latter case the entire contents of the bottle represented the sample.

The analyses of the samples were made immediately upon their receipt in the laboratory, by the chemical methods adopted by the Association of Official Agricultural Chemists.

Cost Per Quart.

The cost as delivered to consumers was practically the same everywhere, namely, eight cents per quart. Any variations from this price for what was understood as retail amounts, two quarts or less, were due in one or two instances to the fact that a producer or dealer was attempting to build up a trade; in the case of samples numbers 54 to 60, inclusive, the price was six cents per quart at the dealers' store; it was not delivered to the homes of consumers. The variations in cost of the nutrients furnished were, therefore, due almost entirely to the differences in the quality of the milk. It should be stated, however, that the price eight cents per quart does not rule throughout the year in all the cities represented; in New Brunswick the price is six cents per quart from May 1st, to November 1st, making the average for the year seven cents per quart.

**The Variations in the Composition or Quality of Milk
Due to Natural Causes.**

Milk is not a product of fixed composition ; both the total amount and the proportions of the constituents contained in it are influenced by a variety of conditions, the chief of which are, perhaps, the individuality of the cow, her breed, food, age and health, and period of lactation, though the time and season of milking are also influencing factors.

Of the classes of constituents constituting the dry matter of milk, viz., butter fat, proteids (chiefly casein and albumen), sugar and mineral salts, fat seems to vary more than the others, though each may vary considerably. Normal milk may be said to contain on the average the following amounts and proportions of the different constituents :

Water.....	87.50 per cent.
"Total Solids".....	12.50 " "
Butter Fat.	3.50 " "
Casein and Albumen	3.75 " "
Milk Sugar.....	4.50 " "
Ash (mineral salts).....	0.75 " "

This average composition has served as the basis in both State and city governments for the enactment of laws or ordinances, the purpose of which is to prevent watering, skimming and other forms of adulteration. The standards adopted seldom require more than 12.50 per cent. of "total solids" and 3.00 per cent. of fat ; thus what may be regarded as the average quality of milk usually exceeds, particularly in fat content, the limit fixed by the various laws. In many instances normal or whole milk will, however, show wide variations from this standard in both directions, that is, it may be very much richer or very much poorer.

The influence of breed, for instance, is very marked, so much so that dairy breeds are classified into milk and butter breeds ; that is, those which give a large quantity of poorer quality and those which give a smaller quantity of a higher quality. The following table contains the average results of a long series of experiments, carried out by the New Jersey Experiment Station with a number of representatives of each of the leading dairy breeds, and confirmed by studies at other institutions, and shows their relative average yields and the average composition of the milk :

Average Yield and Composition of Milk of Different Breeds.

HERD.	Yield per day, in quarts.	PERCENTAGE OF					
		Water.	Total Solids.	Fat.	Casein.	Sugar.	Ash.
Ayrshire.....	9.0	87.30	12.70	3.68	3.48	4.84	0.69
Holstein-Friesian.....	11.0	87.88	12.12	3.51	3.28	4.69	0.64
Shorthorn.....	9.0	87.55	12.45	3.65	3.27	4.80	0.78
Average.....	9.7	87.58	12.42	3.61	3.34	4.78	0.69
Guernsey.....	8.7	86.52	14.48	5.02	3.92	4.80	0.75
Jersey.....	8.4	86.66	14.34	4.78	3.96	4.85	0.75
Average.....	8.6	86.59	14.41	4.90	3.94	4.83	0.75

While these results are not absolute, it is evident that there is a distinct classification of breeds based upon the relative yield and quality of their milk. The milk from animals which naturally produce large quantities shows average quality, and that from animals which produce a smaller quantity shows a quality considerably above the average. That the content of fat in milk varies more than the other constituents, is also distinctly shown in this work.

The effect of food is an important factor, not always appreciated in its influence upon the quality of milk. A specific breed possesses certain capabilities, the value of which is dependent in large measure upon the food that is supplied; that is, while food may not exercise a positive and immediate influence in improving quality of milk, because of the inherent characteristics of the animal to make a product of a definite composition, still unless the animal is supplied with sufficient food she cannot reach her normal capacity in this respect.

The age and health of the animal also affect the composition; young animals produce richer milk than older ones, though much depends upon their health, vitality and vigor. The period of lactation or the length of time which has elapsed after the birth of the calf also exercises an influence upon the composition of the milk; the milk flow is usually greatest, and also poorest, immediately after

calving; as the period increases the flow gradually falls off, and, as a rule, the quality improves. All these influences, however, are not so striking in mixed milk as they are in the milk of individual animals.

The character of the milks examined, and herewith reported, are discussed in the light of these observations concerning the variations in the composition of normal milk.

Discussion of Results of Analysis.

In sampling milk, in the manner described, it is claimed that abnormal variations are quite likely to occur, particularly where milk is dipped from a can—the tendency of the cream is to rise, hence unless the milk is thoroughly stirred after each dipping an undue proportion of the fat would be contained in the samples first taken out; that is, the samples first removed would show a higher content of fat, and the last ones a lower content of fat. Experiments conducted at the Cornell Experiment Station, however, apparently disprove this claim, and the normal character of the majority of the milks examined here seems to verify the results secured there.* Where milk is put up in bottles, particularly if the modern bottling arrangements are used, variations in the composition of different samples of the same lot are not likely to occur.

In the samples obtained from New Brunswick (see Table I.), the variation in "total solids" ranges from 11.82 per cent. to 14.03 per cent., or a difference between highest and lowest of 2.21 per cent. The variation in fat ranges from 2.99 per cent. to 4.57 per cent., a difference of 1.58 per cent. The average composition of the milk, however, is higher than the average composition given as representing normal milk, and in but one case is the variation in the proportion of the different constituents so marked as to indicate that the samples were not fairly representative of whole milk.

In the samples taken from Newark the "total solids" range from 10.81 per cent. to 14.86 per cent., a difference of 4.05 per cent., while the fat ranges from 2.56 per cent. to 6.92 per cent., a difference of 4.36 per cent. The average composition is, so far as "total solids" are concerned, practically identical with the New Brunswick average, though showing a slightly higher percentage of fat. In one sample, No. 57, the content of "total solids" and fat is so low as to create a

* Bulletin No. 20, Cornell Experiment Station.

suspicion of adulteration, and another, No. 59, contains an undue proportion of fat.

In the samples from Trenton the percentage of "total solids" ranges from 10.64 per cent. to 13.96 per cent., a difference of 3.32 per cent. The fat ranges from 2.97 per cent. to 4.80 per cent., a difference of 1.83 per cent., and in one sample only, namely, No. 84, does there appear to be an abnormally low content of "total solids" and fat.

In the samples from Camden the range in "total solids" is from 12.06 per cent. to 16.55 per cent., or a difference of 4.49 per cent. The range in fat is from 3.28 per cent. to 7.76 per cent., a difference of 4.48 per cent. The average composition of the milks of Camden is very much higher than that from the other cities, both in "total solids" and in fat. Two samples only show an abnormal percentage of fat, namely, Nos. 89 and 107.

On the whole, however, the milk-supplies of these cities may be regarded as extremely good, showing an average of—

Total Solids.	Fat.	Casein and Albumen.	Sugar.	Ash.
12.97	4.13	3.37	4.75	0.72

Sources of Supply.

In the case of New Brunswick and Trenton the milk-supply is derived almost entirely from local producers, who deliver the milk themselves. In the cases of Newark and Camden it is derived both from local producers, and from large dealers who procure their supplies from different portions of New Jersey and neighboring States. In Newark very considerable quantities are shipped from Sussex and Warren counties, in New Jersey, and nearby sections of New York and Pennsylvania. In Camden a large portion of the supply comes from the more southern sections of New Jersey.

Such inquiry as was made in reference to the animals in the dairy and the methods of feeding, indicates that the majority of the dairies contained blood of the Channel Island breeds, while in a few pure-bred Jerseys, Guernseys, Holstein-Friesians and Ayrshires were represented.

In a further study of the composition of the samples, these points will be discussed more in detail, as having a possible bearing upon the causes which lead to the variations which occur in commercial milk.

Classification of Samples.

In Table II. the samples have been arranged into eight distinct classes, the first containing those showing less than 3.00 per cent. of fat; the second, those containing from 3.00 per cent. to 3.50 per cent. of fat; the third, those from 3.50 per cent. to 4.00 per cent.; the fourth, those from 4.00 per cent. to 4.50 per cent.; the fifth, those from 4.50 per cent. to 5.00 per cent.; the sixth, those from 5.00 per cent. to 5.50 per cent.; the seventh, those from 5.50 per cent. to 6.00 per cent.; and the eighth, those containing over 6.00 per cent. of fat. In these tables the percentages of "solids not fat" are also shown as having a bearing upon the discussion of the nutritive value of the various classes of milks.

In the first class, but four samples are recorded, in which the "total solids" average less than 12.00 per cent. and the fat is 2.84 per cent., an average composition so low as to lead to the belief that the samples included do not represent the whole milk of well-fed, healthy animals. On account of the fact that these milks were sold at the same price per quart as others of higher quality, they are not excluded from this discussion. It is interesting to observe as having a bearing upon the importance of local supply, that of these four samples three represent milk that was procured in the adjoining States of New York and Pennsylvania.

In the second class, sixteen samples are included, showing an average of 12.15 per cent. "total solids" and 3.34 per cent. of fat.

The third class includes thirty-four samples, one-third of the whole number, the average composition of which exceeds the average assumed for good milk. The remaining samples, forty-eight in number, or nearly half, exceed 13.00 per cent. of "total solids" and 4.00 per cent. of fat.

Character of the Dairies and Rations Fed.

It was possible, too, in many cases to learn the character of the dairies which furnished the milk, particularly in reference to the breed of the animals and the kind of food; for instance, in the first class, three of the four samples represented the product of "common stock" (those of no distinctive breeding or grading, or what are sometimes called "scrub stock"); and in two of the four cases, the rations reported were insufficient to properly nourish cows in full flow of milk.

In the second class eleven out of the sixteen dairies included re-

ported common stock—in one case only was pure-bred animals kept, namely, Jerseys; in four cases grade Jerseys and Holsteins. In seven cases it was possible to secure information concerning rations fed, and out of these two only could be regarded as good.

In class three it was possible to secure data from twenty-six of the thirty-four dairies, and of these eleven reported Jersey or Guernsey grades, the remainder common stock. The rations fed in seven cases were regarded as fairly good.

In class four, out of the twenty-six dairies it was possible to secure data from twenty; nine of these report grade Jerseys, and three pure-bred Jerseys, the remainder common stock. In four cases only were rations given, all of which were good.

In class five, twelve of the thirteen dairies were reported and seven of the twelve consisted of high-grade Jerseys or Guernseys. In three cases only was it possible to secure definite information concerning rations, all of which were good.

In class six, three of the four dairies report Jersey grades, all of which were fed liberal and well-proportioned rations. In class seven the milk is produced by pure-bred Jerseys and Guernseys, and rations well adapted for milk production were fed. Class eight, in one case pure-bred Jerseys, one grade Jerseys, and one pure-bred Guernseys, with no report as to rations.

It will be observed from these data that as the character of the stock is improved by the introduction of the blood of the recognized butter-producing breeds of cows, the quality of the product is materially improved. In the first class all were common stock, in the second 30 per cent. of the dairies contained improved dairy stock. In the third the proportion of improved stock is increased to over 40 per cent. In the fourth it is increased to 60 per cent.; in the fifth it is practically the same, while in the sixth, seventh and eighth the entire number of dairies report either pure-bred or high-grade dairy stock. In other words, the quality of the milk delivered to consumers is very materially influenced by the character of the stock kept.

In the matter of rations, while the facts obtained are interesting and in line with what was to be expected, the data are too incomplete to warrant positive statements.

The Relative Cost Per Pound of Nutrients.

The fact that milk falls into the various classes already indicated, in respect to composition, shows at once that at a uniform price per quart there is a wide variation in the cost of the nutrients to the consumer. Assuming that the quality of the nutrients, as represented by the "total solids," is quite as good in one class of samples as in another, the cost per pound of "total solids" in class one, at the rate of eight cents per quart, or four cents per pound,* is thirty-five cents, while in the eighth class it is twenty-six cents, or 38.5 per cent. greater in class one than in class eight. In other words, \$100 spent for milk of the quality represented by the eighth class would purchase nutriment that would cost \$138.50 if purchased in the form of milk of the quality represented by class one.

These extremes exhibit the range of cost; the average cost would be thirty-one cents, which is fairly representative of class four, which includes about one-fourth of the total number of samples; more than one-half of the total number, however, show a lower quality than the average.

The Quality of the "Total Solids."

The fact that the constituent "fat" in milk varies more than the remainder of the constituents, or "solids not fat," shows that the more expensive nutrients contained in the poorer milks are also less valuable as food than the less expensive nutrients contained in richer milks.

The fat contains about two and one-quarter times as many heat units or "calories" per pound as protein or carbohydrates; hence so far as supplying the needs of the body for heat is concerned, a pound of fat is two and one-quarter times as valuable as a pound of protein or carbohydrates.

It will be observed from a study of the average composition of the milks in the preceding classification, that as the "total solids" in the milk increase for the various classes, the percentage of fat is increased in greater proportion than the "solids not fat;" for instance, in class one, but 25.9 per cent. of the "total solids" is fat; in class two, with slightly over 12 per cent. "total solids" it is increased to 27.5 per cent. In class three, with over 12.50 per cent. "total solids," the fat con-

*On the average, a quart of milk will weigh 2.15 pounds.

stitutes 30.2 per cent. of the total nutrients. In class four, with over 13 per cent. "total solids," the fat is increased to 32.2 per cent. With 13.70 per cent. "total solids" in class five, the fat is 34.2 per cent. In class six, it is 37.2 per cent.; in class seven, 38.2 per cent., and in class eight the fat constitutes 45.8 per cent. of the "total solids" contained in the milk.

In other words, the "total solids" as represented by class six, for instance, contain twenty pounds per hundred more of fat than is contained in one hundred pounds of "total solids" represented by class one. The consumer not only secures his "total solids" in the richer milk at lower cost per pound, but also obtains a product which is very much richer in nutritive matter.

The facts brought out by this investigation in regard to the variation in the cost and quality of the nutrients contained in milk, show very clearly that the standard now in use as the basis of sale, viz, the quart, is illogical, and is unfair both to the consumer and to the producer of good milk.

Assuming that the percentage of fat is a safe guide as to the nutritive value of milk—which assumption is practically borne out by this study—the content of this constituent would better serve as a standard than the quart. For instance, on the average, the milks examined, and for which, at the average price of 8 cents per quart, \$4 per hundred were paid, contained in round numbers 4 per cent., or 4 pounds per hundred of fat. If milk containing 4 per cent. of fat is worth 8 cents per quart, milk containing 3.50 per cent. would, on the same basis, be worth 7 cents per quart; and 3 per cent. milk only 6 cents per quart, while milk containing 4.50 per cent. fat would be worth 9 cents per quart; and 5 per cent. milk 10 cents per quart. If the fat content were adopted, the consumer would be protected in the sense that he would receive just what he paid for, and the producer of a high-quality product the advantage of a higher price which fairly belongs to him, because of the greater cost of producing milk of a better quality.

This method of purchasing milk is now used in many creameries with entire satisfaction, to both the seller and the buyer, and on no account could a creamery that has once adopted it be induced to return to the old method.

To illustrate the disadvantages of purchasing milk as milk, a representative of the Station visited a creamery where the milk was still

purchased in the old way, and took forty-nine samples, representing as many different patrons. The samples were treated with a preservative and shipped to the Station, where the content of fat was determined by Dr. Babcock's method. The results are grouped and classified as follows:

Fat Content of Creamery Samples.

Less than 3 per cent.		3 per cent. to $3\frac{1}{4}$ per cent.		$3\frac{1}{4}$ per cent. to 4 per cent.		4 per cent. and over.	
1 contained 2.6		3 contained 3.1		2 contained 3.5		5 contained 4.0	
1	" 2.7	1	" 3.2	4	" 3.6	1	" 4.1
1	" 2.9	2	" 3.3	4	" 3.7	5	" 4.2
		4	" 3.4	6	" 3.8	2	" 4.3
				5	" 3.9	1	" 4.5
						1	" 4.6

Three averaged 2.7, 10 averaged 3.3, 21 averaged 3.7, 15 averaged 4.2. Average of 49, 3.72 per cent.

The average fat content of the forty-nine samples was 3.7 per cent.; 3 fell below 3 per cent., 10 contained from 3 to $3\frac{1}{4}$ per cent., 21 from $3\frac{1}{4}$ to 4, and 15, 4 per cent. or more.

Assuming that each patron brought 100 pounds of milk a day to the creamery, the patrons in the poorest class delivered on the average 2.7 pounds of butter fat, those in the next class 3.3 pounds, in the next 3.7 pounds and in the best 4.2 pounds, in each case for exactly the same amount of money.

It is evident, therefore, that the 23 patrons who each brought in 100 pounds of milk that was poorer in fat than 3.7 per cent. received a compensation for a total of $8\frac{1}{4}$ pounds of fat that was actually delivered by 26 other patrons to whom no compensation was given whatever. These facts alone are sufficient to show the superiority of the method of paying for the fat delivered, especially in this case, where the object of the creamery is to manufacture this fat into butter.

The purchase of milk on analysis has also been adopted by many large milk depots, where the milk is resold as food, and in addition to the fairness of the method the additional result is inevitably secured that an improvement follows in the quality of milk brought in.

The facts brought out in this investigation indicate that its adoption is quite as important in the purchase of supplies for the home, where the entire product is used as food. It is entirely practicable, too,

under present conditions, for even the smaller producers and dealers to give a reasonably-definite guarantee of the content of fat, because machines are available for testing the fat content of milk, which are inexpensive and simple in operation, and because the chief causes of variations in the quality of milk under improved methods of feeding and management are well known. It remains for the more intelligent consumers and producers alike to demand that the system be adopted.

TABLE I.
Analyses of Samples of Milk.
From New Brunswick.

Sample Number.	Date of Sampling.		Price per Quart.	Total Solids.	Fat.	Casein and Albumen.	Sugar.	Ash.
			cts.					
1	January	30th.	8	13.55	3.94	3.74	5.09	0.78
2	"	"	8	13.00	4.46	3.22	4.97	0.75
3	"	"	8	13.12	4.03	3.31	5.04	0.74
4	"	"	8	13.37	4.44	3.51	4.66	0.76
5	"	"	8	11.83	3.62	2.94	4.56	0.71
6	"	"	8	13.71	4.39	3.47	5.11	0.74
7	February	3d.	8	11.92	3.20	3.24	4.75	0.73
9	"	"	8	13.46	4.43	3.12	5.20	0.71
8	"	"	8	13.28	4.21	3.36	4.97	0.74
10	"	"	8	12.72	3.57	3.48	4.94	0.73
11	"	"	8	13.37	4.26	3.32	5.07	0.72
12	"	"	8	12.55	3.56	3.23	5.04	0.72
13	"	"	6	11.85	3.21	3.21	4.70	0.73
14	"	"	8	14.03	4.54	3.73	4.99	0.77
15	"	"	6	11.82	2.99	3.23	4.88	0.72
16	"	"	8	12.62	3.73	3.20	4.97	0.72
17	"	"	8	12.51	3.79	3.22	4.78	0.72
18	"	"	8	12.48	3.35	3.39	4.93	0.81
19	"	"	8	12.11	3.37	3.22	4.73	0.79
20	"	"	8	12.98	3.85	3.47	4.93	0.73
21	"	"	8	12.53	3.54	3.41	4.83	0.75

TABLE I.—Continued.

Analyses of Samples of Milk.

From New Brunswick.

Sample Number.	Date of Sampling.		Price per Quart.	Total Solids	Fat.	Casein and Albumen.	Sugar.	Ash.
22	February	8d.	cts. 8	12.73	4.01	3.46	4.55	0.71
23	"	"	8	12.20	3.38	3.13	4.97	0.72
24	"	"	8	11.88	3.91	3.16	4.18	0.63
25	"	"	8	13.04	3.97	3.49	4.85	0.73
27	March	20th.	8	14.02	4.57	3.70	4.98	0.77
Average.....				12.83	3.86	3.34	4.86	0.74

From Newark.

31	February	11th.	8	13.44	4.41	3.64	4.66	0.73
32	"	"	8	11.70	3.92	3.09	4.06	0.63
33	"	"	8	12.88	4.07	3.50	4.57	0.74
34	"	"	8	12.83	3.80	3.69	4.57	0.77
35	"	"	8	13.36	4.17	3.60	4.85	0.74
36	"	"	8	13.00	3.99	3.53	4.77	0.71
37	"	"	8	13.15	3.88	3.56	5.00	0.71
38	"	"	8	13.51	4.31	3.51	4.96	0.73
39	"	"	8	12.86	3.98	3.58	4.57	0.73
40	"	"	8	12.91	4.00	3.42	4.79	0.70
41	"	"	8	13.30	4.32	3.41	4.84	0.73
42	"	"	8	11.85	3.36	2.99	4.33	0.67
43	"	"	8	12.61	3.58	3.59	4.71	0.73

TABLE I.—Continued.

Analyses of Samples of Milk.

From Newark.

Sample Number.	Date of Sampling.	Price per quart.	Total Solids.	Fat.	Casein and Albumen.	Sugar.	Ash.
		cts.					
44	February 11th.	8	12.30	3.62	3.33	4.66	0.69
45	" "	8	13.64	4.69	3.56	4.68	0.71
46	" "	8	14.51	4.98	4.06	4.74	0.73
47	" "	8	13.08	4.09	3.33	4.95	0.71
48	" "	8	12.72	3.81	3.54	4.62	0.75
49	" "	8	13.69	4.80	3.31	4.90	0.68
50	" "	8	12.11	3.47	3.38	4.60	0.66
51	" "	8	12.65	3.81	3.45	4.69	0.70
52	" "	8	12.89	3.85	3.36	4.99	0.69
53	" "	8	12.25	3.52	3.45	4.57	0.71
54	" "	6	11.35	2.85	3.16	4.62	0.72
55	" "	6	11.89	3.36	3.08	4.76	0.69
56	" "	6	14.07	4.54	3.99	4.80	0.74
57	" "	6	10.81	2.56	2.09	4.63	0.63
58	" "	6	11.93	3.29	3.46	4.46	0.72
59	" "	6	14.86	6.92	3.09	4.17	0.68
60	" "	6	12.89	4.28	3.11	4.81	0.69
Average.....			12.33	4.01	3.43	4.69	0.71

TABLE I.—Continued.

Analyses of Samples of Milk.

From Trenton.

Sample Number.	Date of Sampling.	Price per quart.	Total Solids.	Fat.	Casein and Albumen.	Sugar.	Ash.
81	February 28th.	cts. 8	12.80	3.50	3.41	4.66	0.78
62	" "	8	13.00	4.30	3.26	4.73	0.71
63	" "	8	12.11	3.30	3.43	4.66	0.72
64	" "	8	12.44	3.47	3.56	4.70	0.71
65	" "	8	13.96	4.80	3.56	4.89	0.71
66	" "	8	13.66	4.80	3.20	4.94	0.72
67	" "	8	12.56	3.97	3.11	4.78	0.70
68	" "	8	12.14	3.85	3.06	4.58	0.65
69	" "	6	13.26	4.26	3.44	4.86	0.70
70	" "	8	13.13	4.13	3.36	4.91	0.73
71	" "	8	12.49	3.31	3.26	5.18	0.74
72	" "	8	12.93	3.81	3.63	4.73	0.76
73	" "	8	11.62	3.71	3.19	4.07	0.65
74	" "	8	12.42	3.63	3.24	4.75	0.75
75	" "	8	12.54	3.83	3.04	4.93	0.74
76	" "	8	12.03	3.25	3.20	4.91	0.67
77	" "	8	12.23	3.81	3.36	4.36	0.70
78	" "	8	12.07	3.66	3.03	4.67	0.71
79	" "	8	12.56	3.81	3.81	4.67	0.77
80	" "	8	13.00	3.82	3.68	4.72	0.78
81	" "	8	12.79	4.03	3.46	4.62	0.68

TABLE I.—Continued.

Analyses of Samples of Milk.

From Trenton.

Sample Number.	Date of Sampling.	Price per quart.	Total Solids.	Fat.	Casein and Albumen.	Sugar.	Ash.
82	February 28th.	cts. 8	13.35	3.89	4.01	4.70	0.75
83	" "	8	13.14	4.02	3.87	4.75	0.70
84	" "	8	10.64	2.97	2.88	4.37	0.62
Average.....			12.60	3.81	3.35	4.71	0.71

From Camden.

85	March 9th.	8	12.81	4.37	3.38	4.38	0.68
86	" "	8	12.17	3.28	3.15	5.05	0.69
87	" "	8	12.51	4.12	3.41	4.29	0.69
88	" "	8	12.66	4.12	3.22	4.61	0.71
89	" "	8	12.06	4.51	2.69	4.25	0.61
90	" "	8	12.04	3.53	3.12	4.71	0.68
92	" "	8	14.58	5.35	3.71	4.81	0.71
93	" "	8	14.16	5.26	3.49	4.73	0.68
94	" "	8	12.71	4.21	3.13	4.70	0.67
95	" "	8	14.18	5.28	3.43	4.83	0.64
96	" "	8	14.89	6.49	3.12	4.62	0.66
97	" "	8	13.70	4.61	3.66	4.74	0.69
98	" "	8	13.54	4.66	3.49	4.67	0.72
99	" "	8	14.72	5.74	3.61	4.65	0.72
100	" "	8	12.51	3.90	3.12	4.80	0.69

TABLE I.—Continued.

Analyses of Samples of Milk.

From Camden.

Sample Number.	Date of Sampling.		Price per quart.	Total Solids.	Fat.	Casein and Albumen.	Sugar.	Ash.
101	March	9th.	cts. 8	13.06	4.18	3.25	4.92	0.71
103	"	"	8	13.41	4.55	3.41	4.71	0.74
104	"	"	8	13.78	4.86	3.32	4.89	0.71
105	"	"	8	13.81	4.46	3.58	5.04	0.73
106	"	"	8	14.95	5.59	3.68	4.92	0.76
107	"	"	8	16.55	7.76	3.21	4.92	0.66
108	"	"	8	14.65	5.37	3.53	5.01	0.74
Average.....				13.62	4.83	3.35	4.74	0.70
Average of all.....				12.97	4.13	3.37	4.75	0.72

TABLE II.

Classification of Samples on the Basis of Their Fat Content.

CLASS 1.

Samples Containing Less Than 3 per cent. Fat.

Sample Number.	Total Solids.	Fat.	Solids not Fat.	Casein and Albumen.	Sugar.	Ash.
15	11.82	2.99	8.83	3.23	4.88	0.72
54	11.85	2.85	8.50	3.16	4.62	0.72
57	10.81	2.56	8.25	2.99	4.63	0.63
84	10.64	2.97	7.67	2.68	4.37	0.62
Average...	11.16	2.84	8.31	3.02	4.63	0.67

CLASS 2.

Samples Containing From 3 to 3.50 per cent. Fat.

7	11.92	3.20	8.72	3.24	4.75	0.73
13	11.85	3.21	8.64	3.21	4.70	0.73
18	12.48	3.35	9.13	3.39	4.93	0.81
19	12.11	3.37	8.74	3.22	4.73	0.79
23	12.20	3.38	8.82	3.13	4.97	0.72
42	11.85	3.36	8.49	2.99	4.83	0.67
50	12.11	3.47	8.64	3.38	4.60	0.66
55	11.89	3.36	8.53	3.08	4.76	0.69
58	11.93	3.29	8.64	3.46	4.46	0.72
61	12.30	3.50	8.80	3.41	4.66	0.73
63	12.11	3.30	8.81	3.43	4.66	0.72
64	12.44	3.47	8.97	3.56	4.70	0.71
71	12.49	3.31	9.18	3.26	5.13	0.74

TABLE II.—Continued.

Classification of Samples on the Basis of Their Fat Content.

CLASS 2.

Samples Containing From 3 to 3.50 per cent. Fat.

Sample Number.	Total Solids.	Fat.	Solids not Fat.	Casein and Albumen.	Sugar.	Ash.
76	12.03	3.25	8.78	3.20	4.91	0.67
79	12.56	3.31	9.25	3.31	4.67	0.77
86	12.17	3.28	8.89	3.15	5.05	0.69
Average....	12.15	3.24	8.81	3.31	4.79	0.72

CLASS 3.

Samples Containing from 3.50 to 4 per cent. Fat.

1	13.55	3.94	9.61	3.74	5.09	0.78
5	11.83	3.62	8.21	2.94	4.56	0.71
10	12.72	3.57	9.15	3.48	4.94	0.73
12	12.55	3.56	8.99	3.23	5.04	0.72
16	12.62	3.73	8.89	3.20	4.97	0.72
17	12.51	3.79	8.72	3.22	4.78	0.72
20	12.98	3.85	9.13	3.47	4.98	0.73
21	12.53	3.54	8.99	3.41	4.83	0.75
24	11.88	3.91	7.97	3.16	4.18	0.63
25	13.04	3.97	9.07	3.49	4.85	0.73
32	11.70	3.92	7.78	3.09	4.06	0.63
34	12.83	3.80	9.03	3.69	4.57	0.77
36	13.00	3.99	9.01	3.53	4.77	0.71
87	13.15	3.88	9.27	3.56	5.00	0.71

TABLE II.—Continued.

Classification of Samples on the Basis of Their Fat Content.

CLASS 3.

Samples Containing From 3.50 to 4 per cent. Fat.

Sample Number.	Total Solids.	Fat.	Solids not Fat.	Casein and Albumen.	Sugar.	Ash.
39	12.86	3.98	8.88	3.58	4.57	0.73
40	12.91	4.00	8.91	3.42	4.79	0.70
43	12.61	3.58	9.03	3.59	4.71	0.73
44	12.30	3.62	8.68	3.33	4.66	0.69
48	12.72	3.81	8.91	3.54	4.62	0.75
51	12.65	3.81	8.84	3.46	4.69	0.70
52	12.89	3.85	9.04	3.36	4.99	0.69
53	12.25	3.52	8.73	3.45	4.57	0.71
67	12.56	3.97	8.59	3.11	4.78	0.70
68	12.14	3.85	8.29	3.06	4.58	0.65
72	12.98	3.81	9.12	3.63	4.73	0.76
73	11.62	3.71	7.91	3.19	4.07	0.65
74	12.42	3.68	8.74	3.24	4.75	0.75
75	12.54	3.88	8.71	3.04	4.93	0.74
77	12.23	3.81	8.42	3.36	4.36	0.70
78	12.07	3.66	8.41	3.03	4.67	0.71
80	13.00	3.82	9.18	3.68	4.72	0.78
82	13.35	3.89	9.46	4.01	4.70	0.75
90	12.04	3.53	8.51	3.12	4.71	0.68
100	12.51	3.90	8.61	3.12	4.80	0.69
Average...	12.57	3.79	8.79	3.37	4.85	0.71

TABLE II.—Continued.

Classification of Samples on the Basis of Their Fat Content.

CLASS 4.

Samples Containing From 4 to 4.50 per cent. Fat.

Sample Number.	Total Solids.	Fat.	Solids not Fat	Casein and Albumen.	Sugar.	Ash.
2	13.00	4.46	8.54	3.22	4.57	0.75
3	13.12	4.03	9.09	3.31	5.04	0.74
4	13.37	4.44	8.93	3.51	4.66	0.76
6	13.71	4.39	9.32	3.47	5.11	0.74
9	13.46	4.43	9.03	3.12	5.20	0.71
8	13.28	4.21	9.07	3.36	4.97	0.74
11	13.37	4.26	9.11	3.32	5.07	0.72
22	12.73	4.01	8.72	3.46	4.55	0.71
31	13.44	4.41	9.03	3.64	4.66	0.73
33	12.88	4.07	8.81	3.50	4.57	0.74
35	13.36	4.17	9.19	3.60	4.85	0.74
38	13.51	4.31	9.20	3.51	4.96	0.73
41	13.30	4.32	8.98	3.41	4.84	0.73
47	13.08	4.09	8.99	3.33	4.95	0.73
60	12.89	4.28	8.61	3.11	4.81	0.69
62	13.00	4.30	8.70	3.26	4.73	0.71
69	13.26	4.26	9.00	3.44	4.86	0.70
70	13.13	4.13	9.00	3.36	4.91	0.73
81	12.79	4.03	8.76	3.46	4.62	0.68
83	13.14	4.02	9.12	3.67	4.75	0.70
85	12.81	4.37	8.44	3.38	4.38	0.68

TABLE II.—Continued.

Classification of Samples on the Basis of Their Fat Content.

CLASS 4.

Samples Containing From 4 to 4.50 per cent. Fat.

Sample Number.	Total Solids.	Fat	Solids not Fat.	Casein and Albumen.	Sugar.	Ash.
87	12.51	4.12	8.39	3.41	4.29	0.69
88	12.66	4.12	8.54	3.22	4.61	0.71
94	12.71	4.21	8.50	3.13	4.70	0.67
101	13.06	4.18	8.88	3.25	4.92	0.71
105	13.81	4.46	9.35	3.58	5.04	0.73
Average...	13.13	4.23	8.90	3.39	4.83	0.72

CLASS 5.

Samples Containing From 4.50 to 5 per cent. Fat.

14	14.03	4.54	9.49	3.73	4.99	0.77
27	14.02	4.57	9.45	3.70	4.98	0.77
45	13.64	4.69	8.95	3.56	4.68	0.71
46	14.51	4.98	9.53	4.06	4.74	0.73
49	13.69	4.80	8.89	3.31	4.90	0.68
56	14.07	4.54	9.53	3.99	4.80	0.74
65	13.96	4.80	9.16	3.56	4.89	0.71
66	13.66	4.80	8.86	3.20	4.94	0.72
89	12.06	4.51	7.55	2.69	4.25	0.61
97	13.70	4.61	9.09	3.66	4.74	0.69
98	13.54	4.66	8.88	3.49	4.67	0.72
103	13.41	4.55	8.86	3.41	4.71	0.74
104	13.78	4.86	8.92	3.32	4.89	0.71
Average...	13.70	4.69	9.01	3.51	4.78	0.72

TABLE II.—Continued.

Classification of Samples on the Basis of Their Fat Content.

CLASS 6.

Samples Containing From 5 to 5.50 per cent. Fat.

Sample Number.	Total Solids.	Fat.	Solids not Fat.	Casein and Albumen.	Sugar.	Ash.
92	14.58	5.35	9.23	3.71	4.81	0.71
93	14.16	5.26	8.90	3.49	4.73	0.68
95	14.18	5.28	8.90	3.43	4.83	0.64
108	14.65	5.37	9.28	3.53	5.01	0.74
Average...	14.39	5.32	9.08	3.54	4.84	0.69

CLASS 7.

Samples Containing From 5.50 to 6 per cent. Fat.

99	14.72	5.74	8.98	3.61	4.65	0.72
106	14.95	5.59	9.36	3.68	4.92	0.76
Average...	14.84	5.67	9.17	3.65	4.79	0.74

CLASS 8.

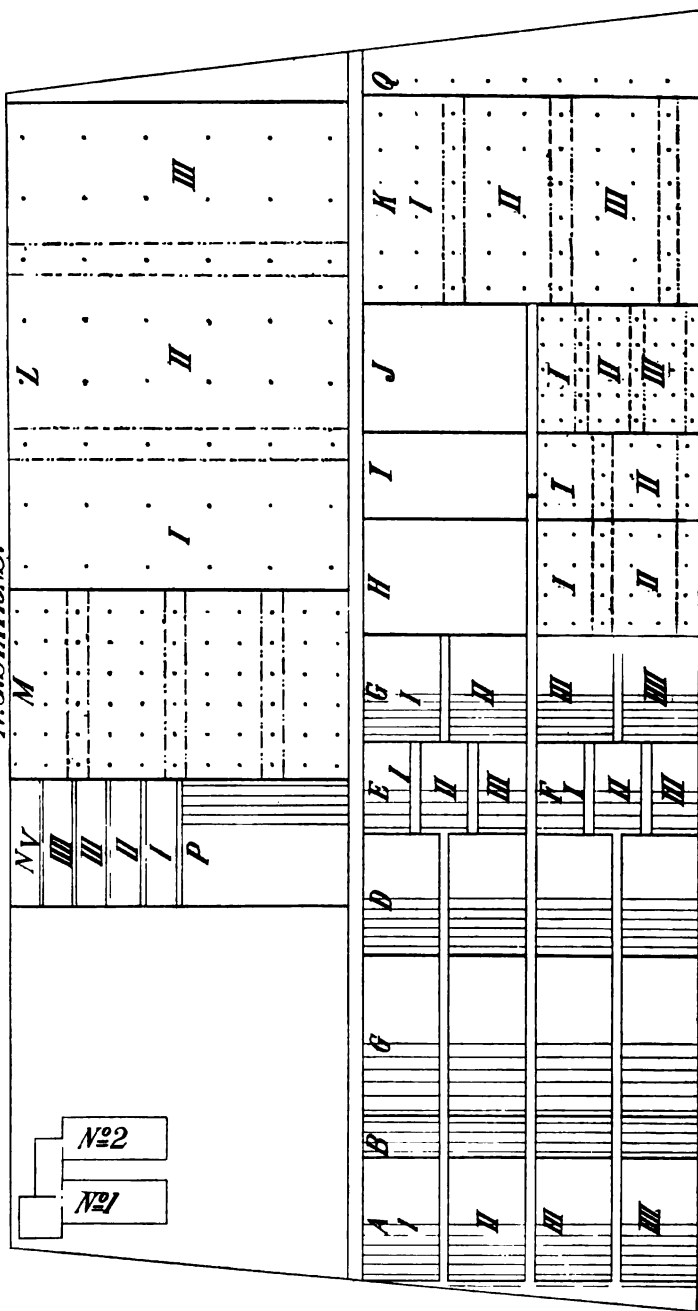
Samples Containing Over 6 per cent. Fat.

59	14.86	6.92	7.94	3.09	4.17	0.68
96	14.89	6.49	8.40	3.12	4.62	0.66
107	16.55	7.76	8.79	3.21	4.92	0.66
Average...	15.43	7.06	8.38	3.14	4.57	0.67

TABLE III.

	PERCENTAGE OF—			Percentage of Fat in Total Solids.
	Total Solids.	Fat.	Solids not Fat.	
Class 1.....	11.16	2.84	8.31	25.9
" 2.....	12.15	3.34	8.81	27.5
" 3.....	12.57	3.79	8.79	30.2
" 4.....	13.13	4.23	8.90	32.2
" 5.....	13.70	4.69	9.01	34.2
" 6.....	14.39	5.32	9.08	37.2
" 7.....	14.84	5.67	9.17	38.2
" 8.....	15.43	7.06	8.38	45.8

EXPERIMENT GROUNDS.
N.J. STATIONS.



**REPORT OF THE ASSISTANT IN
HORTICULTURE.**

(159)

The application of the fertilizer was made in the row at time of setting in the case of the asparagus and small fruits except strawberries, upon which it was spread broadcast, while upon the tree fruits one-half was applied in the hole with the remainder spread broadcast. The application of manure was also made in the row at the time of setting, 18 tons per acre being used.

Asparagus.—Divisions A and B are devoted to this vegetable—A, to cultural tests with standard varieties, B to similar tests with selected plants and new varieties.

A. Six varieties have been selected for study in this division. Five varieties only have been set; roots of the sixth variety were unobtainable this spring. Those already set are: Barr's Mammoth, Donald's Elmira, Columbian Mammoth White, Palmetto and Conover's Colossal. The rows are 5 feet apart, with the roots 2 feet 8 inches apart in the row, or 15 plants of each variety in each plot. Referring again to the diagram, the arrangement and numbers of the plots are given. The same culture has been given all plots this year. For fertilizer, in addition to that applied at time of setting, *i. e.*—

Plot 1.—Manure at the rate of 18 tons per acre.

Plots 2, 3 and 4.—General fertilizer at the rate of 650 pounds per acre. Plot 3 received November 2d an even mixture of ground bone and muriate of potash at the rate of 300 pounds per acre. Plot 4 received July 22d nitrate of soda 200 pounds per acre, and November 2d bone and potash 300 pounds per acre.

On account of the attack of the asparagus rust, so prevalent in New Jersey this year, the tops were cut early in the fall, weights in all cases recorded and samples taken for analysis.

B. Four varieties are to occupy this division, one of which is still lacking. In the first two rows A 1, selected crowns of Donald's Elmira and Palmetto are used, and the influence of well-selected roots was very apparent this year in the growth of tops, in one case nearly double, in the other more than one-fourth larger than in the same varieties as set in the other section. The new variety, "Moore's Cross-Bred," was set in the third row. Distances, fertilizers and treatment of different plots are the same as in A.

C. *Blackberries*.—Six varieties set in rows 7 feet apart and 4 feet apart in the row, or 10 plants per plot, occupy this division. Early Harvest, Wilson, Jr., Erie, Agawam, Taylor, Eldorado are the

varieties used. The greater part of the plants used in plots 2, 3 and 4, also several in plot 1, failed to live, and hence were reset in the fall.

In addition to the general fertilizer used, plot 3 received an even mixture of bone and potash at the rate of 300 pounds per acre, applied November 2d. Plot 4 also received the above mixture, and had the plants lived would have received an addition early in the summer of nitrate of soda.

D. Raspberries.—Again six varieties are used, set in rows 5 feet apart, 3 feet distant in the row, 13 plants each per plot. The varieties selected are: Cuthbert, Marlboro, Turner, Champlain, Gregg and Souhegan. Practically all the plants in the last three plots failed to live and were reset in the fall. An even mixture of bone and potash was applied November 2d to plots 3 and 4, at the rate of 300 pounds per acre. Plot 4 was to receive 200 pounds per acre of nitrate of soda in early summer, provided plants had lived.

E. Currants.—Four varieties, Fay's Prolific, Red Dutch, Victoria and White Grape, occupy 3 plots. Rows are 6 feet apart, plants 3½ feet distant, or 7 plants each per plot. Plot 3 received July 23d nitrate of soda at the rate of 150 pounds per acre. November 2d an even mixture of bone and potash was given plots 2 and 3 at the rate of 500 pounds per acre.

F. Gooseberries.—Downing, Columbus, Houghton and Triumph, 7 plants each per plot. Distances and fertilizer treatment the same as in the case of the currants.

G. Strawberries.—Six varieties set in rows 4 feet apart, plants set about 21 inches distant in the row. Sharpless, Bubach, Downing, Timbrell, Gandy and Marshall are the varieties selected for study. In addition to the general fertilizer, plots 2 and 3 received in early summer nitrate of soda at the rate of 150 pounds per acre. No manure is used upon this fruit.

H. Plums.—Four varieties, Lombard, Newman, on peach stock, Shropshire, Damson and Grand Duke, have been selected for plot work, setting at a distance of 15 feet each way. With this fruit, as with all the tree fruits, two trees of each variety are used in each plot and in each test. In past experiments with tree fruits carried on by the Station,* it was found that unless the plots were separated by a considerable distance, inter-feeding took place. To obviate this, the plots have been separated by a cross line of trees of different varieties

*Annual Report 1894, p. 122. Conclusion of experiment.

introduced for this purpose and incidentally to test, in a small way, the different varieties. Hence in each row trees 1, 2, 4, 5, 7, 8, 10 and 11 are for plot work, while the 3d, 6th, 9th, etc., are of different varieties separating the plots.

In addition, then, to the above four sorts, two trees, each of the following varieties, have been included in this division :

Imperial Gage,	Burbank,
Victoria,	Abundance,
Bavay's Green Gage,	French Damson,
Washington,	Satsuma Blood.

I. Cherries.—Distance and arrangement same as in the case of the plums. The varieties selected are, for plot work : Large Montmorency, Louis Philippe and Early Richmond ; for variety tests and separating plots, two each, Osheim, Royal Duke, English Morello, Montmorency Ordinaire, May Duke and Reine Hortense.

J. Dwarf Pears.—The first two rows are dwarf pears proper ; the other three rows are standard trees, set to be dwarfed by severe cutting and pruning. Trees are set 10 by 12 feet. Of the dwarf trees proper, Lawrence and Bartlett are used in the plots with two trees each of the following varieties between plots : Margaret, Clapp's Favorite, Howell, Angouleme, White Doyenne and Seckel. Standards to be dwarfed by cutting : In plots—Lawrence, Bartlett and Keiffer. Between plots : Anjou, Le Conte, Clairgeau, Clapp's Favorite, Seckel, Sheldon, Howell, Margaret and Belle Lucrative.

K. Standard Pears.—Six varieties have been selected for the special study, i. e., Lawrence, Bartlett, Keiffer, Clapp's Favorite, Sheldon and Seckel ; 18 by 20 feet are the distances used for these trees. Between the plots are set two trees each of Koonce, Angel, Idaho, P. Barry, Flemish Beauty, Giffard, Dorset, Winter Nelis and Lady Clapp.

Under Q is indicated a single row of trees. This consists of two trees each of Lawrence, Bartlett and Keiffer, and one each of Clapp's Favorite, Sheldon and Seckel, and are fall set according to the method as described in the "New Horticulture" by H. M. Stringfellow.

L. Apples.—Six varieties, set 30 by 30 feet, occupy the plots of this division. They are Baldwin, Smith's Cider, Jonathan, Gravenstein, Duchess of Oldenburg and King of Tompkins County. Between

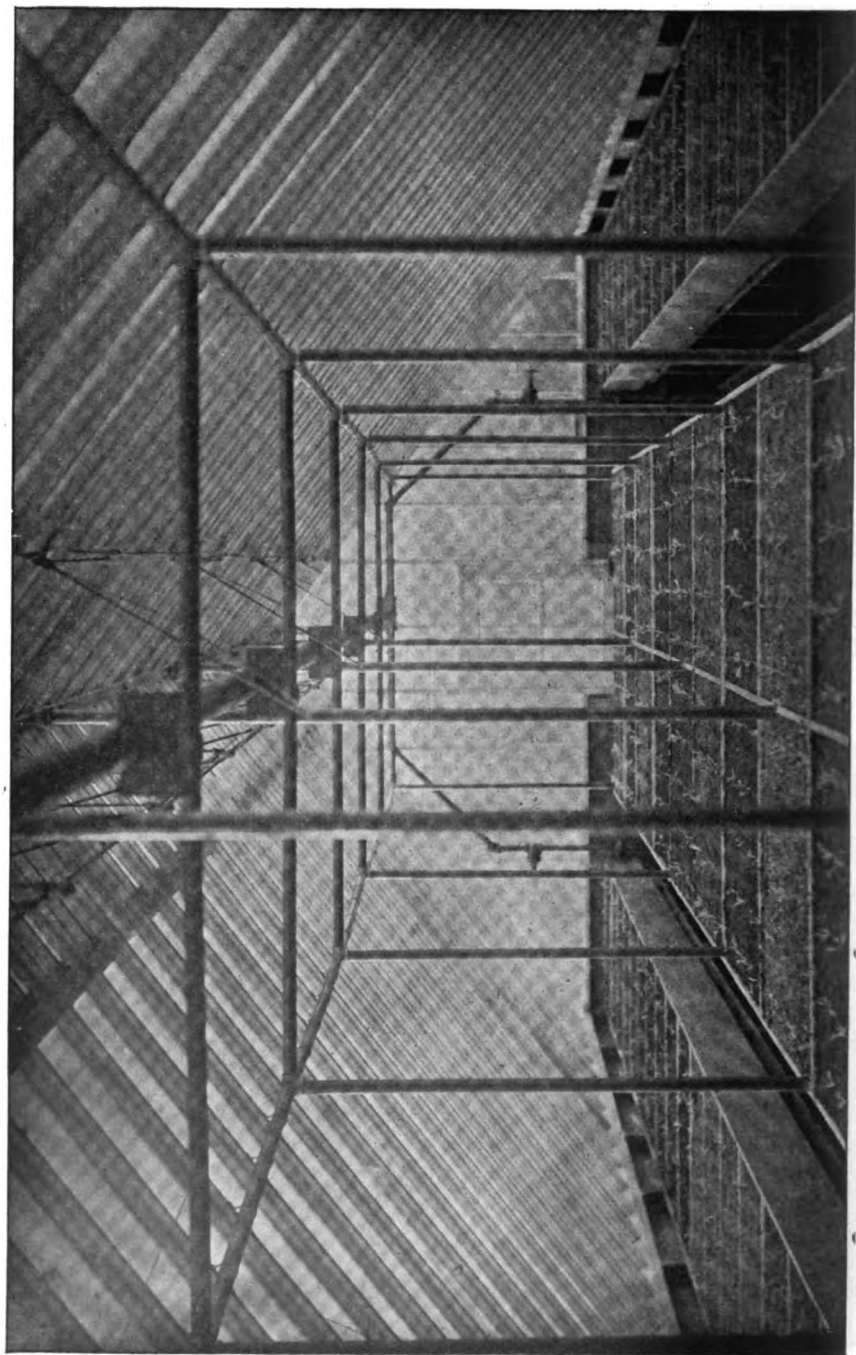


PLATE I.

plots are set two each of Stump, Yellow Transparent, Williams' Favorite, Ben Davis, Monmouth Pippin and Barry.

M. Peaches—The trees are set 15 by 16 feet, six varieties being included in the plot work. These are Old Mixon, Reeves' Favorite, Crawford's Late, Elberta, Stevens' Rareripe and Susquehanna. The following are set between the plots: Triumph, Wonderful, Wager, Ward's Late, Champion, Butler's Late, Sneed, Walburton's Admirable and Surpasse Melocoton.

This completes the description of the regular fruit plots. In addition, a few novelties or new varieties of small fruits have been set out in division P. These include one-half dozen plants each of Columbian, Loudon, Miller, Superlative and Gault raspberries, the Logan berry (a raspberry-blackberry), White Imperial currant and Red Jacket gooseberry.

Here also are two rows devoted to a study of sub-irrigation for small fruits. The varieties used are the same as in the regular plots, and include four varieties of currants, three of gooseberries and three of raspberries.

Additional work with strawberries has also been undertaken amongst the plums and cherries of divisions H and I. Hill culture with three varieties of strawberries, at different distances, are to be compared with the same in matted row, and a modified matted row system. Two dozen plants each of about thirty varieties have been set for comparison. These varieties include those mentioned fifteen or more times in the replies as given in our fruit census reported last year, and also varieties selected from lists reported in the horticultural papers as being the best for market use.

Vegetables.—The present year the Station has entered quite largely into variety-testing, especially of beans and peas, the tests including recent introductions and old standard sorts.

Every gardener in a small way must carry out such tests for himself, since he has soils and conditions peculiarly his own; but from the work of the Station he can get a good idea of the comparative merits of the different varieties and materially reduce the number of varieties he might select for trial on his own grounds.

The Station can warn purchasers against inferior seeds and sorts, and also against old sorts offered under a new name with highly-colored plates and high prices.

Variety-testing, to be of value, must extend through a period of years, for, as well known, a variety doing well under the conditions of one year's growth may do exactly the opposite under the conditions arising in succeeding years. Our aim is to continue the work another year, at least, and bring out other points of value in connection with the different sorts, their culture and management.

The season has generally been quite favorable for plant growth. At no time during the growing-season were we without rain for any long period, the average monthly rainfall for the four growing-months of May, June, July and August was 3.85 inches, June giving the highest (4.93 inches), August the lowest (2.42 inches).

Besides the variety tests of beans and peas, tests have also been made of different thicknesses of planting, using varieties representing different types of these vegetables. A study of variations of results from duplicate tests has also been undertaken, using again varieties representing typical forms. Two varieties of each, from several different seedsmen, have been grown the present year to study the question, Do varieties run out? With peas, an additional test has been made of training as against ordinary field culture.

The bush limas have also received attention.

Of tomatoes, a few varieties only have been grown the past year. These include some of the more recent introductions. Earliness of maturing has been studied with three varieties, using plants from early and late-sown seed. In the same connection, methods of handling have been considered. Four early varieties were treated with different forms and combinations of fertilizers, to determine their influence, if any, upon earliness, beginning with the starting of the seed in the house and continuing in the field until the fruits began to ripen.

An intensive system of double cropping with horticultural crops in connection with a fertilizer test was started the present year, occupying the plots indicated in division N of the diagram. These plots are one twenty-fifth of an acre in area and received fertilizers as shown below :

Plot 1.	
Check.	
Plot 2.	
Yard manure, 800 lbs.	
Plot 3.	
Muriate of Potash,	7 lbs.
Acid Phosphate,	14 "
Plot 4.	
Potash,	7 lbs.
Phosphate,	14 "
Nitrate of Soda,	6 "
Plot 5.	
Potash,	7 lbs.
Phosphate,	14 "
Nitrate of Soda,	2 "
Dried Blood,	6 "

One-half of each plot was devoted to beans ; the other half to peas. As soon as these crops were gathered, the vines were removed and late sweet corn was planted. This crop had sufficient time to mature before the first killing frost occurred, October 9th.

The first week of September, crimson clover was sown in the corn. It is expected to turn this under and repeat the experiment another year. Samples of typical forms of the beans, peas and corn have been taken for analysis in connection with this work.

Data in the shape of weights, yields, dates of maturing, etc., have been taken of all this work and recorded for future use.

At O of the diagram is indicated the position of the forcing-houses, showing the ground area—the accompanying plate gives the general appearance. They consist of two parallel houses, 50 by 20 feet, connected at the north end by a smaller lean-to house, 28 by 10 feet dimensions, and a head-house, in which is a small office for the assistant in horticulture and a potting and workroom. In the cellar of the head-house is a Hopson & Chapin hot-water boiler for heating the houses.

The coming winter the houses are to be occupied with soil and fertilizer tests in forcing vegetables. House No. 1 has upon the side benches a test of five different soils, each receiving four different treatments with fertilizers. Each plot has an area of 7 square feet growing 15 lettuce plants set 8 by 8 inches. In the center bed arrangements have been made for surface-watering, sub-irrigation, and also at one end a solid bench has been provided. An artificial soil and soils containing different percentages of humus (peat) are here used. The plate gives the appearance of No. 1 just after being filled with lettuce. Radish had been planted, but does not show. No. 2 is to be used in growing cucumbers and tomatoes. Here, as in No. 1, different soils with different fertilizers are to be used, as also surface-watering and sub-irrigation for tomato-forcing.

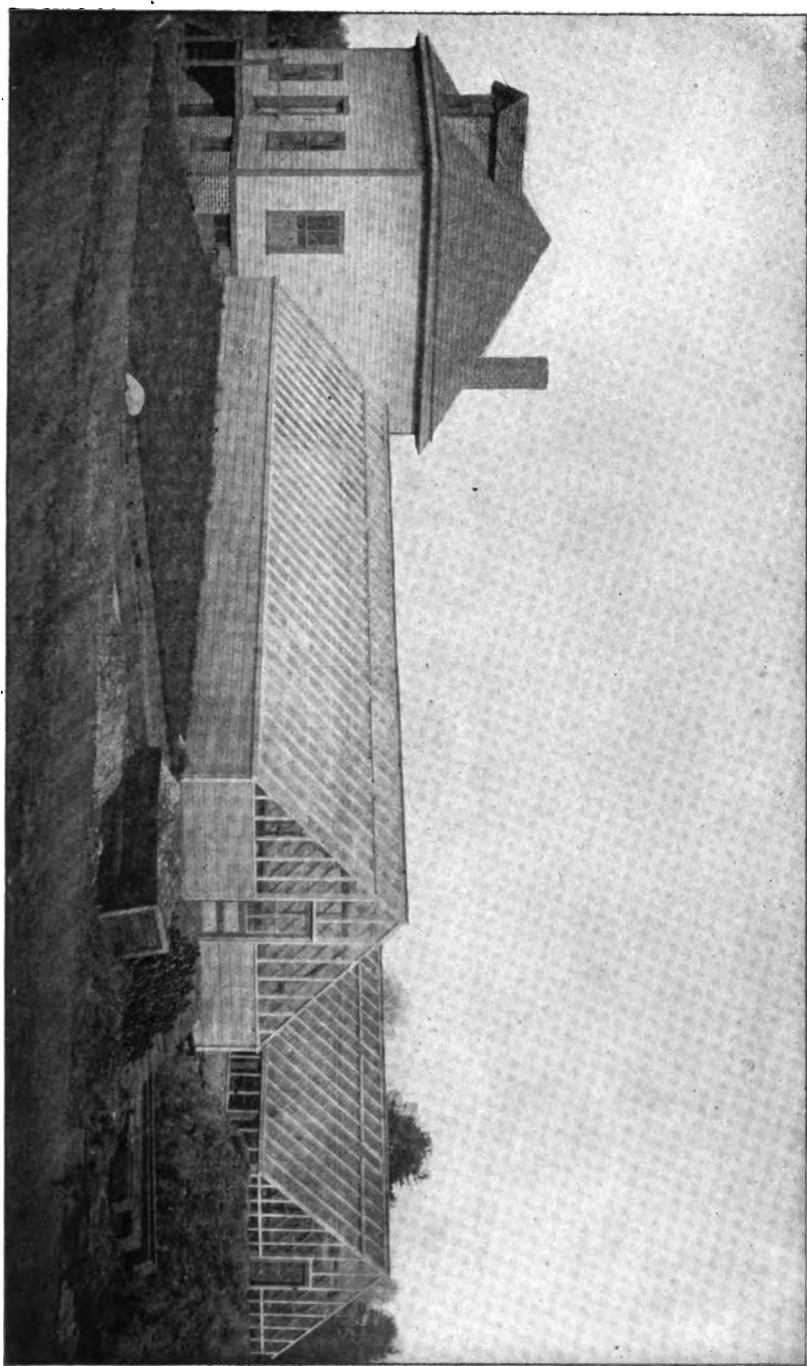


PLATE II.

**REPORT OF THE ASSISTANT IN DAIRY
HUSBANDRY.**

(169)

fed not longer than twelve days. Any crop may be fed for a longer period by planting or sowing successively small areas. Rotations can be planned so that two and even three crops may be grown on the same piece of land each year. The different fodder crops, with methods of treatment and yield, are discussed in the order in which they were used through the season. All crops were sampled for analysis, and the final results will be discussed on the basis of actual food produced.

RYE, WHEAT, AND CRIMSON CLOVER.

About one acre each of these crops was sown in the fall of 1895 for soiling purposes. No record of the labor was kept. The rye was ready for cutting May 1st, and yielded 6 tons per acre. The wheat was cut ten days later and yielded 5 tons per acre. The entire area of the crimson clover did not survive the winter; it yielded at the rate of 7 tons per acre. Following the crimson clover, grass from meadow lands, mostly timothy, was fed for a few days until the oats and peas were ready for cutting.

OATS AND PEAS.

This was one of the most profitable green crops grown. Canada field peas and oats were sown broadcast at the rate of two bushels of each per acre. The peas were sown immediately after plowing and harrowed in before sowing the oats, which were harrowed but once, and the field rolled, in order to leave the ground in good condition for cutting the crop with a mowing machine. Careful record was kept of the time of seeding, labor, fertilizer, cutting, hauling, yield, etc. It will be noticed in the table below that each plot was ready for cutting about two months from time of seeding. The time required for one man to cut and haul a ton of green fodder varied from three to five hours, according to the kind of fodder and distance from the barn. This work was performed by the herdsman, who would otherwise have been idle, hence the actual cost of harvesting the green crops was a small item. The cost per ton, not including hauling to the barn, ranged from \$1.04 to \$1.32 per ton.

Cost and Yield of Oats and Peas Per Acre.

Number of Plot.	Date of Seeding.	COST OF—						Period of Cutting and Feeding.	Total Yield—Tons.	Total Cost.
		Labor.	Seed.		Fertilizer.					
			2 bushels Oats.	2 bushels Peas.	150 lbs. Muriate of Potash.	100 lbs. Acid Phosphate.				
1st acre.....	April 15.....	\$2.40	\$0.60	\$2.65	\$8.00	\$0.60	June 20-30.	7.00	\$9.25	
2d acre.....	April 25.....	2.35	60	2.65	8.00	60	July 1-12.	8.57	9.20	
3d acre.....	May 12.....	2.28	60	2.65	8.00	60	July 12-24.	8.71	9.08	

CORN.

This is one of the best crops for soiling. If planted about May 1st, it will be ready for cutting in a little over two months. Four acres were used for forage during the summer. It was planted in drills three and one-half feet apart, and the stalks stood as nearly as may be one foot apart in the drill. This crop received yard manure at the rate of 6 tons per acre in addition to the fertilizer, which should be taken into consideration in making comparisons of the cost of product. The time required for harvesting a ton was approximately the same as for the oats and peas.

Cost and Yield of Corn Per Acre.

Date of Seeding.	COST OF—						Period of Cutting and Feeding.	Yield—Tons.	Total Cost.
	Labor.	Seed.	Fertilizer.						
			100 lbs. Acid Phos- phate.	100 lbs. Muriate of Potash.	100 lbs. Ground Bone.	6 tons Manure.			
May 15.....	\$6.06	\$0.12	\$0.60	\$2.00	\$1.40	\$0.00	July 20-Aug. 2	11.00	\$19.18

THE COW PEA.

This is a crop which is grown more largely for green manuring than for forage, though certain varieties are well adapted for the latter purpose. Two acres of the "Clay" variety were grown. The first was sown broadcast June 11th, after the land had been plowed and harrowed once with the Acme harrow, at the rate of one and one-half bushels of seed per acre. The seed was then well harrowed in and rolled. This acre was ready for cutting by the middle of August, and yielded 7.48 tons. The second acre was sown in drills $2\frac{1}{2}$ feet apart August 27th. Twenty-eight quarts of seed were used. The peas on this acre grew very slowly, although they were cultivated several times and kept free from weeds. The yield on this acre was 4.75 tons. Our experience this year seems to indicate that sowing broadcast is preferable to sowing in drills, as the yield is much larger, and the cost of production less. The second acre had to be cut with a hand scythe, so that the cost of harvesting was greater than the first acre. It required approximately four hours for one man to harvest a ton on the first acre.

Cost and Yield of Cow Peas Per Acre.

Number of Plot.	Date of Seeding.	COST OF—						Period of Cutting and Feeding.	Yield—Tons.	Total Cost.
		Labor.	Seed.	100 lbs. Muriate of Potash.	Acid Phos.		100 lbs. Ground Bone.			
					150 lbs.	100 lbs.				
1st acre.....	June 11.....	\$2.10	\$1.88	\$2.00	\$0.90	.....	.....	Aug. 15-25.	7.48	\$6.88
2d acre.....	June 27.....	2.85	1.09	2.00	.....	\$0.60	\$1.40	Aug. 25-Sept. 2.	4.75	7.94

THE SOJA BEAN.

This is an annual leguminous plant, requiring about the same treatment as the cow pea. It grows tall and shrub-like and gives a fair yield on good soil. It requires a somewhat richer soil than the cow pea. One-half acre of the green variety was sown in drills $2\frac{1}{2}$ feet apart July 1st, at the rate of one bushel per acre. One-half acre

adjoining was sown with a white variety. The green beans made a fair growth, nearly shading the ground, and yielded three tons on the half acre. A blight attacked the white variety soon after they came up and stopped their growth, so they were not worth cutting. Cost of cutting and hauling same as for first acre of cow peas.

Yield and Cost of Soja Beans (Green Variety).

Plot.	Date of Seeding.	COST OF—					Period of Cutting and Feeding.	Yield—Tons.	Total Cost.
		Labor.	Seed— $\frac{1}{4}$ bushel.	Fertilizer.					
				50 lbs. Ground Bone.	50 lbs. Acid Phosphate.	50 lbs. Muriate of Potash.			
$\frac{1}{2}$ acre.....	July 1.....	\$1.65	\$0.75	\$0.70	\$0.30	\$1.00	September 1-5.	3.00	\$4.40

BARLEY AND PEAS.

Two acres of this crop were sown broadcast after taking off a crop of oats and peas. The first acre was seeded July 25th and the second August 10th. Two bushels of Canada peas and two bushels of barley were used per acre. They supplied feed during the first half of the month of October, each acre yielding 6 tons. This crop is not injured by frost, and is one of the best for late feeding. The cost of cutting and hauling is practically the same as for oats and peas.

Yield and Cost of Barley and Peas per Acre.

Number of Plot.	Labor.	Date of Seeding.	COST OF—								Period of Cutting and Feeding.	Yield—Tons.	Total Cost.
			Seed.		Fertilizer.								
			Barley.	Peas.	Ground Bone.		150 lbs. Muriate of Potash.	100 lbs. Acid Phosphate.	25 lbs. Nitrate of Soda.	25 lbs. Dried Blood.			
1st acre..	\$2.30	July 25.	\$2.00	\$2.65	\$1.40	.....	\$2.00	\$0.60	.....	.....	Oct. 1-8	6.00	\$10.95
2d acre..	2.00	Aug 11.	2.00	2.65	.....	\$2.13	2.00	.....	\$0.25	\$0.47	Oct 8-16.	6.00	11.50

The food of the dairy herd was varied in character by the use of these crops. The Canada peas, cow peas and soja beans were rich in protein, while rye, oats, barley and corn were more carbonaceous and all very palatable. Enough green food was cut every morning to last one day except Saturday, when a two days' ration was harvested. Most of the fodders were cut with a mowing machine and carted to the barn by the herdsman in a one-horse dump-cart. The green fodder was fed in the barn morning and night, each cow receiving from 50 to 70 pounds per day, according to the size of the cow and the kind of fodder fed. This, with a grain ration of 8 pounds, consisting of 3 pounds wheat bran, 3 pounds brewers' grains (dried), 1 pound hominy meal, and 1 pound linseed meal (O. P.), supplied the feed for the summer. The nutritive ratio of this full ration was approximately 1 : 6. During the summer months, the herd was confined to a two-acre inclosure, and were healthy and vigorous, and ate heartily during the whole time.

SOME OF THE ADVANTAGES OF SOILING OVER PASTURE.

Cows can be fed regularly and a uniform quantity ; they can use all their energy in the production of milk, there is none lost in searching for food ; no food is wasted, no manure is wasted ; more cows can be kept on a given acreage, and much of the expense of fencing is saved.

GENERAL STUDY OF THE DAIRY HERD.

The herd at the present time is made up of 26 cows, 6 heifers and a Guernsey bull. The cows are mostly grades of the following breeds : Holstein, Jersey, Guernsey, Ayrshire and Shorthorn. The weight of each cow's milk has been kept since April 1st, and it has been analysed for content of butter fat at least once a month. The following table shows the variation in quantity and quality of milk from month to month. The records below, with the exception of No. 13, are from cows which were milked during the whole seven months.

Number of Cow.	April.		May.		June.		July.		August.		September.		October.	
	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.
	lbs.	p. c.	lbs.	p. c.	lbs.	p. c.	lbs.	p. c.	lbs.	p. c.	lbs.	p. c.	lbs.	p. c.
8....	1,116.1	3.5	1,152.1	3.7	982.6	3.9	859.6	4.7	729.8	4.4	681.5	4.4	429.0	4.4
9....	1,074.6	3.2	1,117.3	3.6	976.0	3.9	839.9	3.8	787.3	4.2	735.2	4.1	543.6	4.4
11...	650.8	3.5	807.2	3.7	822.3	3.8	695.3	4.5	638.3	3.8	694.5	4.0	548.0	3.9
13...	374.7	6.1	407.7	6.3	306.1	6.5	.....	.....	562.3	5.9	516.6	6.3	408.2	7.4
20...	949.0	4.8	987.1	4.6	890.8	4.4	749.2	4.6	654.0	5.0	506.3	5.3	288.6	5.9

The feeding of green fodder began May 1st, and the effect on the quantity of the milk produced is very striking. Every cow, without exception, gave more pounds of milk in May than in April, and with but one exception, No. 20, every cow increased the per cent. of butter fat in her milk, which indicates that previous to May 1st the conditions of feeding were not such as to favor a normal product. During the months following, it will be seen that there is a gradual decrease in the milk flow with most of the cows as they advance in the period of lactation, and there is also a gradual increase in the per cent. of butter fat from the same cause.

Another point studied in this connection is the question of the variations in the quality of mixed or herd milk under uniform conditions of feeding and management, though under varying conditions of milk flow of individual animals due to changes in the period of lactation. This work is in line with the suggestions offered by the study of the cost and composition of milk as delivered to consumers, viz., that milk should be sold on the basis of quality, and that the fat content is a measure of quality. The results secured are certainly encouraging, and indicate that with a careful observation of the conditions which affect quality, a reasonable uniformity may be attained; that is, the tabulation shows the content of butter fat which could have been guaranteed the consumer during each month; but little variation is shown after the first of May, yet during these six months there were cows going dry and new ones coming in.

Average Per Cent. of Fat in the Mixed Milk of the Whole Herd.

April.	May.	June.	July.	August.	September.	October.
p. c.	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.
2.9	4.2	4.3	4.3	4.4	4.3	4.4

This work is to be continued in connection with a study of practical methods, by which the sale of milk on the basis of quality may be attained.

METHODS OF SEEDING CRIMSON CLOVER.

In connection with a study of this plant, both as forage and as green manure, the following experiments were made:

Plot I. consisted of one acre planted with corn. It was seeded July 9th, at which time the corn was nearly five feet high, without previous preparation of the soil. Most of the seed germinated, but the dry weather which followed caused an uneven stand.

Plot II. This plot was well prepared previous to seeding, and the plot then divided into three sections. The first section was simply rolled, the second harrowed with a smoothing harrow, and the third worked with a Breed's weeder. In November there was a good stand of clover on all the sections, and practically no difference in the appearance of the clover on the whole plot.

Plot III. This plot of four acres was sown on the surface, between the rows of corn, July 13th, and then cultivated in. It came up well, nearly covered the ground when the corn was cut (September 1st), and showed on November 1st a good stand from four to six inches high.

Plot IV. also contains four acres. The corn was cultivated July 15th, and the clover then seeded on the top of the loose soil. The seed germinated well and made a good growth before the corn was cut. November 1st it appeared about the same as on No. III.

Plot V. contains three acres. The corn was cultivated and the seed sown on the surface July 17th, as in plot IV., and immediately afterward worked in with a Breed's weeder. This came up very thick, and was a better catch than on Plots III. and IV., and showed

an even stand and better growth in November. The corn on a part of this plot was taken off early in August. Where this was done the clover made double the growth, showing in a striking manner the advantages of moisture and sunshine.

Plot VI. This plot was of raw ground, one acre in area, thoroughly prepared previous to seeding, July 27th, and harrowed in with a smooting harrow and rolled. This showed the best growth of any in November, except where the corn was taken off from plot V. It covered the ground well and stood six to eight inches high.

Plot VII. This plot was sown in August after the land was thoroughly prepared, and by the first of November it compared favorably with plots sown in July.

All the above plots were seeded with Delaware-grown clover. Plots III. and IV. were duplicated by two plots, which received the same treatment, except they were seeded with one-year-old foreign-grown seed. The growth from the two kinds of seed in November is in favor of the Delaware seed. The above experiments indicate that the catch and fall growth of this plant are promoted when the land is thoroughly prepared and the seed well worked in. If the season is favorable the seed may catch and make a good growth if simply sown on the surface.

THE EXPERIMENTAL SILO.

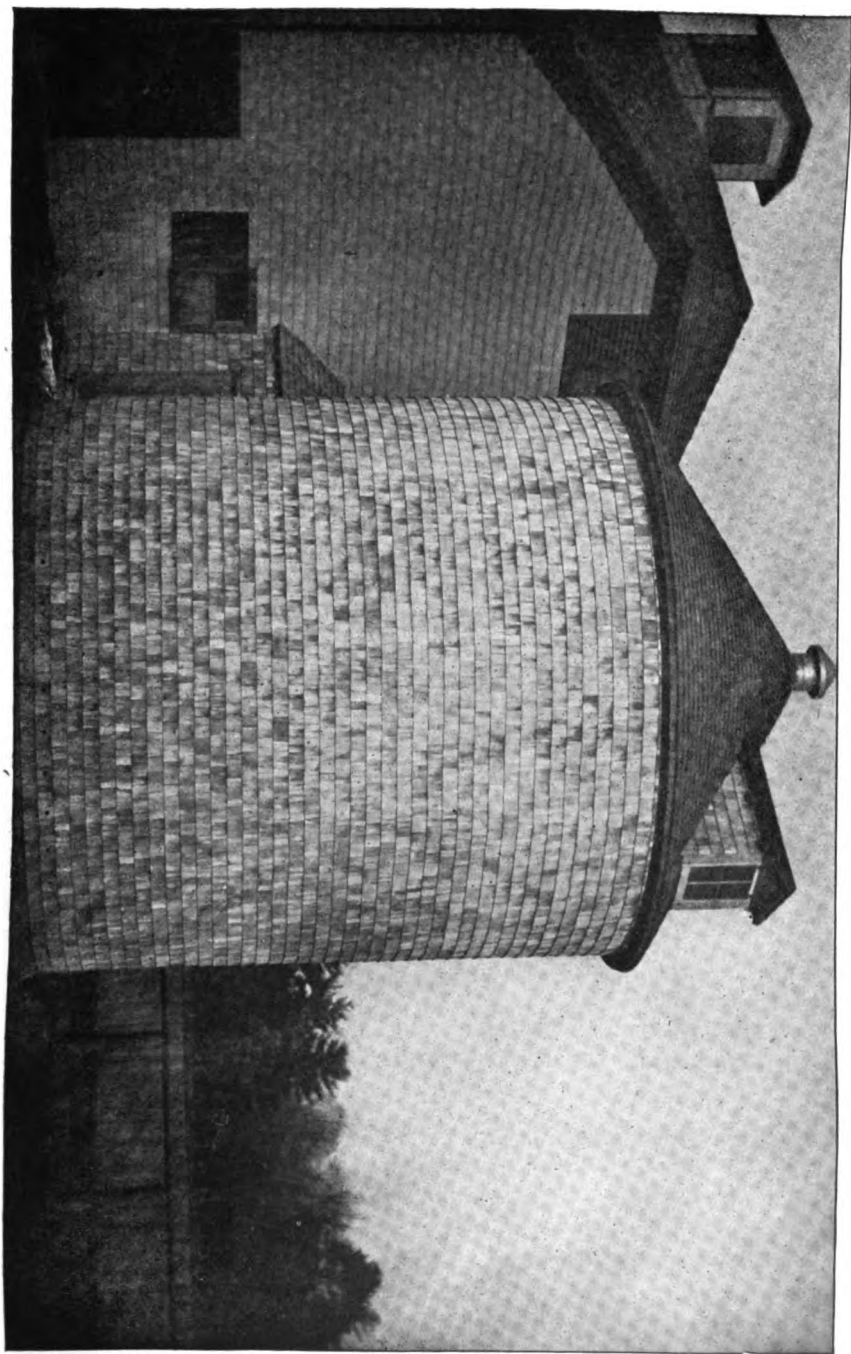
Careful experiments as well as continued practice have demonstrated that good silage, when properly used, is an excellent food, particularly for dairy cows. It has also been shown that under many conditions it is one of the cheapest of our bulky foods; that it is the best and cheapest under all conditions has not yet been proven, though the knowledge gained in recent years concerning savings that may be made in silo construction and in methods of preserving it makes its use a question worthy of careful consideration by all dairymen. In order to study the question under conditions that may be regarded as unfavorable, so far as cost of labor is concerned, which is the chief item of expense, an experimental silo, which is shown in the accompanying cut, was erected this year by the Stations. After a careful study of the various suggestions in reference to kind,* it was believed

* Wisconsin Experiment Station Report 1893, p. 215. Silos and Silage, Farmers' Bulletin No. 32, U. S. Department of Agriculture, by C. S. Plumb. A Book on Silage, by F. W. Woll.

that the round form possessed advantages, both in cost and in preventing loss, not possessed by the square or rectangular form ; that is, the round one is cheaper to build as an isolated structure, and having no corners, presents less opportunity for waste. In the first place, the preservation of the crop put into the silo depends upon the exclusion of the air, hence it should have as great a depth as possible, and as little surface as is consistent with the amount required daily, in order that in filling the air may be pressed out, and in using that a sufficient depth of the surface may be removed at each feeding to prevent spoiling by being exposed to the air for too long a period. In the second place, the silo should be tight, in order to prevent access of air after the crop is put in ; and while it is claimed that a lining of matched boards will accomplish this, it is much safer to have a double lining, with tarred paper between. It is, however, not necessary to put on an outer covering, though adding much to the appearance of the structure. The silo has been condemned in many cases because the above points have not been observed in the building. Cheapness in construction as the only principle does not pay in the long run ; strength and durability and a knowledge of the purposes should rather be the guide in structure.

THE COST OF THE SILO.

The cost of a silo of a definite capacity will, of course, vary in different localities, owing to variations in cost of labor, lumber, brick, stone, etc. The items of cost, not including labor, are given for the one here described, which has a capacity of 150 tons. It is 21 feet inside diameter and 24 feet deep, with a brick foundation 1 foot wide and carried 2 feet below the surface of the ground ; the bottom is cemented and is $1\frac{1}{2}$ feet below the sills. The sills are made from 2 by 6 studding, cut on the slant of a radius of the silo circle, bedded in mortar and toe-nailed together ; the plates are made in the same way and spiked to studs, which are 2 by 4 and 1 foot apart. The lining consists of two thicknesses of half-inch spruce boards with tarred paper between. The siding consists of one layer of boards as above, covered with cedar shingles ; holes bored between each stud and covered with wire netting (see cut), permit a circulation of air between the siding and lining, which aids the preservation of the lining. The structure is roofed, as shown, with dormer window for



filling and with ventilating cap, and is joined to the barn with passage and floor 6 by 8 feet, also roofed. Four doors, $2\frac{1}{2}$ feet square, are cut in the siding for emptying the silo, the silage dropping through a chute 2 feet square upon the floor of the passageway, which is connected by a door with the feeding floor of the barn.

COST OF MATERIALS REQUIRED IN BUILDING.

Foundation—2,500 brick.....	\$5 50 per M.	\$13 75
Cement, $7\frac{1}{2}$ barrels ordinary.....	1 35 " bb'l.	10 46
Cement, $1\frac{1}{2}$ barrels Portland.....	4 00 " "	5 00
Sand, 4 loads.....	1 50 per load.	6 00
Studding, 2 by 4 by 24 (704 feet).....	20 00 " M.	14 08
Plates and sills, 2 by 10 by 12 (260 feet).....	20 00 " "	5 20
Studding for passage, 2 by 4 by 16 (85 feet).....	20 00 " "	1 70
Siding and lining 5,200 feet.....	17 50 " "	91 00
Shingles, 14,000	4 00 " "	56 00
Nails, 2 kegs	3 25 " keg.	6 50
Boards for roof, 325	17 50 " M.	5 69
Paper, 6 rolls.....	1 50 " roll.	9 00
Total		\$224 38

The cost of labor is not included, as this item is likely to be more variable than the materials, besides a large amount of the work can be performed by the farmer himself, or his regular laborers. The items are given solely as a guide as to probable maximum outlay for materials which it is necessary to buy for a structure of this form and capacity.

Detailed information concerning silos and their construction may be obtained from the sources indicated in the foot-note.

Experiments are now in progress to study the relative cost of the nutrients contained in, and the advantages of silage, as compared with corn fodder, the results of which may be expected in future reports and bulletins.

A REPORT ON IRRIGATION.

BY THE DIRECTOR.

(188)

IRRIGATION IN NEW JERSEY.

The question of irrigation in what are regarded as the humid, or regions of sufficient annual rainfall of this country, is beginning to receive considerable attention, and the interest now aroused may be traced rather to changes which have taken place in the character of the farming than in any marked change in the character of the seasons and in the annual rainfall.

In New Jersey, as well as in other Eastern States contiguous to the large cities, there has been a rapid increase in the area devoted to market-garden products, fruits and berries, or crops of relatively high value, and a corresponding decrease in the area devoted to old-line farming crops, or to crops of comparatively low value. This change in the nature of the crops grown is, as a rule, accompanied by a change in practice, that is, what is known as the "intensive" system of farming is more largely adopted; large quantities of manures are applied and crops rapidly succeed each other, all supplied with an abundance of food. Furthermore, earliness and high quality of products are of relatively greater financial importance than formerly, and these conditions cannot be secured without a continuous and abundant supply of water. The wider dissemination of accurate information concerning the principles which govern in the management of soils and in the feeding of crops, and the means now afforded for combating insects and diseases, enable the producer at the present time to largely control the conditions other than the weather. The late frost in spring and early frost in autumn, floods, and the spring and mid-summer droughts are still beyond his control, and the frequency of the latter are the cause of very great losses annually.

The lack of water, particularly for quick-growing vegetables, small fruits and berries, not only seriously affects both their yield and quality, but many times causes utter ruin. The necessity of utilizing all the means at hand for overcoming these difficulties is, therefore, apparent and justifies a careful inquiry concerning the possibilities of

irrigation in those regions in which crops are more or less injured from year to year, either through a lack of sufficient rainfall or through its unequal distribution. In carrying out the investigation here recorded, particular inquiry was therefore made along the following lines :

1. Need of irrigation in New Jersey.
2. Area capable of being watered by gravity, and accessible water-supply for this purpose.
3. Estimated cost of irrigation in these sections.
4. Use of irrigation in the State, methods used, and the results secured.
5. Irrigation experiments in New Jersey.

The meteorological records of the State afford abundant proof that there is a very frequent shortage of water during the growing-season, due both to a deficiency in rainfall and to its unequal distribution, and that the most serious shortage occurs in those sections peculiarly adapted for the growth of vegetables and small fruits.

The data in reference to rainfall in connection with careful measurements of the flow of streams, show that the State possesses a large supply of water for purposes of irrigation, which careful surveys indicate may be made accessible at a reasonable expense.

That this valuable resource of the State may be utilized with profit is illustrated by the examples given, derived from actual experience. The financial returns secured in these cases were profitable, even though those engaged in the work were inexperienced in all matters pertaining to irrigation. With proper knowledge of methods, the advantages derived doubtless would have been very much greater.

The experimental plant now in operation on the farm connected with the New Jersey Stations has for its object the study of the necessity of irrigation for a wide variety of crops, the amount of water required and the various methods of application.

Mr. C. C. Vermeule, of New York City, an accomplished engineer and author of "Water-Supply," Geological Survey of New Jersey, 1894, furnished the data concerning the need of irrigation, the water-supply accessible for the purpose, and the estimated cost of irrigation plants; and Mr. George A. Mitchell, of Vineland, N. J., secured much statistical matter in reference to a number of the irrigation plants now in operation in the State.

THE NEED OF IRRIGATION IN NEW JERSEY.

The need of irrigation in some portions of the State has been seriously felt several times during the past fifteen years, and especially during the year 1895, which is still fresh in memory. This need is not apparent when we merely consider the average rainfall throughout the State, which varies from 44.09 inches in the northwest to 49.70 inches on the seacoast, the main law of change observable being a quite steady decrease as we go inland from the coast. It is nevertheless a fact, however, that our entire rainfall occasionally sinks as low as 31.5 inches in localities, which is as low as the annual rainfall on the borders of the sub-humid region of the West, and also that droughts occur during the growing-months from April to August, inclusive, even more frequently than is popularly supposed. If even one of these months shows a serious deficiency of rainfall below the average, some crop is likely to suffer. In order to show how often this has occurred in the past we have compiled Table No. 1 from the longest series of rainfall records obtainable. This table shows what percentages of the years covered by the records in each case show a deficiency of one inch or more below the average rainfall. Taking each month by itself we find that the longer records show generally that the deficiency occurs about one-third of the time. The fact that it is less for Moorestown and Vineland for certain months is only due to the shortness of the records. The second part of the table shows a fact which is more serious, namely, that during the seventy years covered by the Philadelphia record, 88 per cent. of the years show at least one month of this critical period deficient, while 56 per cent. show two or more months deficient and 30 per cent. three or more months. The only reason that New York shows a less proportion is that the record does not include the years from 1825 to 1835, which were dry ones, and after a careful analysis of all the rainfall records of the State we are convinced that during this period of seventy years any part of the State would have been subject to as great and as frequent droughts as are shown by the Philadelphia records.

TABLE No. 1.

Percentages of Years in Which Rainfall During Growing-Months
Has Been One Inch or More Below the Average.

	Years of Record.	April.	May.	June.	July.	August.	DEFICIENCY FOR—		
							One Month.	Two Months.	Three Months.
New York.....	1836-95	33	35	35	33	39	75	42	21
Newark.....	1844-95	32	28	36	40	32	.....	.....	.....
New Brunswick.....	1854-95	35	28	32	47	40	.....	.....	.....
Philadelphia.....	1825-95	34	32	32	37	38	88	56	30
Moorestown.....	1879-95	7	27	27	33	27	.....	.....	.....
Wineland.....	1868-95	2	34	29	50	40	.....	.....	.....

Observation confirms what we should naturally expect, that our average rainfall is that which is most conducive to luxuriant vegetation—that is, to good crops. We should expect this because this average represents conditions which have generally caused our State to be productive, but if we turn to the records of rainfall we find that those years which approximate the average in amount and distribution of the rainfall have almost invariably been very productive ones. Perhaps we cannot illustrate this better than by recalling the abundant crops during, and just after the War of the Rebellion.

TABLE No. 2.

Rainfall of Average and of Some Deficient Years.

Newark.				
	April to August.	Spring.	Summer.	Year.
1880.....	17 88	8.96	13.32	37.34
1881.....	11.28	11.45	6.66	39.00
1882.....	14.61	10.89	6.91	51.70
1885.....	14 94	6.49	10.48	43.59
1894.....	10.42	7.69	4.62	40.60
1895.....	19 14	10.00	11.88	39.53
Average.....	20.38	11 46	12.83	46.70

New Brunswick.

1880.....	17.79	7.90	14.76	37.17
1881.....	11.32	8.42	8.47	38.46
1882.....	15.86	10.76	7.72	48.66
1885	15.41	5.23	11.26	36.70
1894.....	16.43	11.02	7.00	48.06
1895.....	10.68	10.68	11.62	39.25
Average.....	21 34	11.37	13.74	46.89

Philadelphia.

1880.....	17.47	6.50	14.50	33.58
1881.....	9.33	7.15	6.01	30.21
1882	16.85	10.75	9.67	45.58
1885.....	16.19	6.99	9.89	33.35
1894*..	23.12	18.56	6.70	55.68
1895*.....	16.38	11.73	8.62	35.90
Average.....	19.89	10.74	12.48	43.35

Vineland.

1880.....	22.63	10.95	18.03	51.71
1881.....	13.01	10.10	8.18	42.48
1882.....	20.26	11.69	12.88	54.01
1885.....	13.16	6.36	7.71	35.43
1894.....	24.62	18.72	7.71	55.19
1895.....	17.49	13.48	8.09	38.36
Average	19.69	11.22	12.98	47.87

We find from our rainfall records that the period from 1860 to 1866 shows a remarkably uniform rainfall during the growing-months, generally close to the average. In Table No. 2 we have compared the rainfall for certain notably dry years of recent occurrence with the average rainfall for certain stations which fairly represent the State. For the first four of these years the relative severity of the droughts is well exhibited by the deficiency of the rainfall for the five growing-months of April to August. In 1881, the driest year of all, this deficiency ranged from 9 to 10.5 inches, although Vineland shows but about 7 inches. The year 1885 shows generally about 6.5 inches deficiency. The years 1881 and 1894 were so dry as to cause the forests in the northern part of the State to turn brown, and numbers of trees were actually killed, showing that the limit of endurance of the forests had about been reached. We find that at Newark the deficiency from

* Moorestown.

April to August was 9.1 inches in 1881, and 9.96 inches in 1894. The average deficiency for the northeastern part of the State was probably about the same for both years. The severity of the drought of 1894 is not well shown in the rainfall from April to August at New Brunswick, Philadelphia and Vineland, but taking the summer rainfall alone it becomes more apparent. So in 1895 the tables fail to show the full severity of the drought, but the following table exhibits it more satisfactorily for both these years.

RAINFALL DURING DROUGHTS OF 1894 AND 1895.

	MAY TO AUGUST.			JUNE TO AUGUST.		
	1895.	Average.	Deficit.	1894.	Average.	Deficit.
Kittatinny and Highlands.....	13.92	16.23	2.31	5.21	12.35	7.14
Red Sandstone Plain.....	14.87	16.90	2.13	6.43	12.86	6.43
Southern Interior.....	11.45	17.82	6.37	6.95	13.22	6.27

This table is made up from the average of a large number of stations for each district, taken from the records of the State Weather Service, to which we are indebted for much of our data. The drought of 1894 was confined to the summer months, and was slightly more severe in northern than in southern New Jersey when measured by the deficiency of rainfall alone. The drought of 1895 was much less severe in northern than in southern New Jersey, owing to the fact that it set in one month later, September showing about 1 inch of rainfall, while the deficiency up to the end of August had only been about 2 inches, whereas in southern New Jersey, August showed only about an inch of rainfall, and September the same amount. It is interesting to compare the amount of rainfall shown in these tables with that of western Kansas, where the mean annual temperature is about the same as that of southern New Jersey, and where irrigation has been found to be necessary for profitable agriculture. In those places at which the average rainfall is about 20 inches per annum, that of spring is 4.7 inches, and that of summer 7.9 inches,

making a total of 12.6 inches for the two seasons. It will be seen that the above dry periods approach these figures. Another interesting comparison is that of Table No. 3, which we have compiled from the report of the Kansas State Board of Agriculture for the quarter ending December 31st, 1889. This shows the rainfall and crop conditions where the average yearly rainfall happens to be almost exactly that of our driest years, and that from April to August averages 20.50 inches, while our Kittatinny Valley and Highlands average 19.75 inches, the Red Sandstone Plain 20.53, and the Southern Interior 21.67 inches for the same months. The temperature is also much the same as that of our Southern Interior.

TABLE No. 3.

Rainfall and Crop Conditions, Riley County, Kansas.

YEAR.	RAINFALL.				YIELD IN BUSHELS PER ACRE.			
	April to August.	Spring.	Summer.	Year.	Wheat.	Corn.	Oats.	Potatoes.
1872.....	24.84	9.79	15.97	35.78	14	38	25	68
1873.....	22.47	10.92	12.28	29.08	15	45	33	132
1874.....	8.12	3.75	4.74	17.73	11	2	16	5
1875.....	10.75	5.17	6.69	17.96	14	41	28	90
1876.....	34.20	17.21	20.95	45.78	13	40	30	100
1877.....	25.68	14.68	13.70	43.79	15	45	50	52
1878.....	26.45	7.88	20.39	39.10	16	42	48	67
1879.....	20.00	5.00	15.00	36.13	11	45	35	50
1880.....	21.03	5.32	16.21	29.11	11	32	24	73
1881.....	13.36	8.98	5.13	28.94	9	17	37	14
1882.....	20.71	9.70	11.68	28.35	22	50	45	80
1883.....	24.86	8.24	17.67	36.79	19	40	50	80
1884.....	23.43	10.22	15.57	33.62	23	47	41	110
1885.....	15.88	8.33	7.55	24.90	12	30	40	100
1886.....	19.96	11.18	10.33	28.85	16	25	35	75
1887.....	17.46	5.81	12.07	29.88	8	12	30	80
1888.....	17.73	6.11	14.10	31.29	19	29	36	20
1889.....	22.07	9.78	14.18	30.87	22	50	41	.....
Average.....	20.50	8.78	13.01	31.55	15	35	36	65
Average value per bushel, New York, 1890-1894.....					\$0.84	\$0.55	\$0.28	\$0.40
Average per acre of good crop, 1882-1884, bushels.....					21	46	45	90
Excess of good over average.....					6	11	9	25
Value of excess per acre, good over average.....					\$5.04	\$6.05	\$2.52	\$10.00
Average per acre of bad crop, 1874, 1881, 1887.....					9	10	28	33
Excess of good over bad per acre.....					12	36	17	37
Value of excess per acre, good over bad.....					\$10.08	\$19.80	\$4.76	\$14.80

This table we shall have occasion to refer to later in another connection. It will be seen that it presents quite a wide range of crop conditions, which gives it much of its value. The years 1882 to 1884 inclusive, were very fruitful ones and they show that with spring and summer rainfall amounting to from 22 to 25 inches in all, that country will yield 21 bushels of wheat per acre, 46 bushels of corn, 45 bushels of oats and 90 bushels of potatoes, whereas the average crop for the 18 years has been wheat 15, corn 35, oats 36 and potatoes 65 bushels. This is a striking illustration of the influence of rainfall in determining the yield of crops. It will be noticed that the total rainfall from April to August for these best years is about the same as the average for our own State, while the poorest years exhibit conditions quite similar to our own driest years. Thus we have in 1874, 8.12; in 1875, 10.75; in 1881, 13.36, and in 1887, 17.46 inches of rainfall, and in all these years most of the crops are very poor. If we compare the dry years in Table No. 2 we notice that the rainfall from April to August ranges from about 9.33 up to 17.79 inches, excepting in a few cases already pointed out, where the total from April to August does not fairly represent the severity of the drought. Taking the rainfall by seasons the above table shows a range for the driest season of the poor years of from 3.75 to 5.81 inches, while Table No. 2 shows a range of from 4.62 up to 8.62 inches. In general it will be seen, therefore, that while the yearly rainfall averages only about three-quarters as much as that of our own State, the rainfall during the growing-months is quite similar both in its range and its average. It appears that if, during this period, the crop could have been maintained as high as it was in 1882, 1883, 1884 and 1889, when rainfall was sufficient, the annual gain in crop per acre would have been 6 bushels of wheat, 11 bushels of corn, 9 bushels of oats and 25 bushels of potatoes, which, at the value per bushel given, would have amounted to an average of \$5.60 per acre on these four crops, or 34 per cent. of the value of an average crop. It will further be found that the average loss on bad crops, due to light rainfall, amounts to \$12.36 or 71 per cent. of the value of an average crop. The rainfall conditions during the growing-season are very similar to those which prevail in New Jersey. We give this only as an illustration, for the probabilities are that irrigation would have produced still better crops than we have taken as the standard, because even when the rainfall as a whole is sufficient,

there will often be months or parts of months in which the drought will be so severe as to, to a certain extent, injure the crop, besides it is highly probable that irrigation in New Jersey will be applied to the raising of much more valuable crops than those above taken for illustration, and the gain for these crops will be at the same rate per cent. as for the less valuable crops of our illustration. We may therefore, without attempting exact estimates of what the profit of irrigation will be where so much depends upon the character of the crop and the efficiency of treatment, safely consider that an outlay of \$10 per acre per annum will afford a wide margin for profit in the hands of a good farmer. It is a well-known fact that the returns from irrigation have, in very many cases been such as would give an ample profit on a cost of \$10 per acre annually. The above table, No. 3, makes it appear, then, that there is a good promise of profit in such irrigation as will supply, at all times, in New Jersey, moisture equal to that of an average year.

Table No. 4 shows the average rainfall and temperature over the four important divisions of the State. This makes clear the important bearing of temperature upon the relative dryness of these different sections. It is well known that droughts are felt in an increasing degree as we proceed from the Kittatinny Valley and Highland region southward, but the table shows that the average rainfall increases in like manner, so that our driest section is the one having the largest average rainfall. The temperature, however, increases with the rainfall, and it has been fully established in the investigations of the run-off of streams (Report on Water-Supply, Geological Survey of New Jersey, 1894) that evaporation increases about 5 per cent. for each increase of one degree in mean temperature of the atmosphere. It will be seen from the table that between the Kittatinny Valley and the Highland regions and the Southern Interior there is a difference of 4.2 degrees in the temperature for the year, which corresponds, therefore, to an increase of 21 per cent. in the evaporation. This higher temperature fully accounts for the greater frequency of droughts in southern New Jersey, and it is also seen in Table No. 2 and context that the greater average rainfall of that section is not accompanied by a greater rainfall during the driest seasons, which may be as dry here as elsewhere, consequently during such seasons the large increase of evaporation makes the drought more severe in this part of the State than farther north.

TABLE No. 4.

Average Rainfall in Inches and Temperature in Degrees Fahrenheit.

	KITTATINNY VALLEY AND HIGHLANDS.		RED SANDSTONE PLAIN.		CLAY AND MARL REGION.		SOUTHERN INTERIOR.	
	Rain.	Temperature.	Rain.	Temperature.	Rain.	Temperature.	Rain.	Temperature.
January	3.48	26.8	3.63	28.5	3.73	29.5	3.83	30.5
February	3.31	27.7	3.45	31.0	3.55	32.2	3.64	33.5
March	3.57	33.8	3.72	36.8	3.82	38.0	3.93	39.3
April	3.48	47.2	3.63	49.4	3.73	50.0	3.83	50.7
May	3.88	58.8	4.04	60.8	4.16	60.9	4.27	61.5
June	3.88	67.6	4.04	69.6	4.16	70.1	4.27	70.6
July	4.06	71.3	4.23	74.3	4.35	74.6	4.46	75.0
August	4.42	68.6	4.59	71.3	4.71	71.9	4.84	72.6
September	3.57	61.7	3.72	64.5	3.82	65.1	3.93	65.7
October	3.33	50.1	3.45	53.6	3.55	53.8	3.64	54.1
November	3.57	40.4	3.72	43.4	3.82	44.0	3.93	44.7
December	3.57	29.8	3.72	32.5	3.82	33.3	3.93	34.1
Year	44.09	48.5	45.94	51.3	47.22	52.0	48.52	52.7
Spring	10.93	46.6	11.89	43.8	11.71	49.6	12.08	50.5
Summer	12.85	69.2	12.86	71.7	13.22	72.2	13.57	72.7
Autumn	10.47	50.7	10.89	53.8	11.19	54.3	11.50	54.3
Winter	10.36	27.6	10.80	30.7	11.10	31.7	11.40	32.7

The Report on Water-Supply already referred to, embodies the results of extended studies of the relation between rainfall, evaporation and demands of vegetation and the raising and lowering of the ground-water. While these investigations were made with a view to determining the capacity of the streams of the State, they also have a direct application to this subject of irrigation, and the reader is referred to that report, and especially to pages 329 to 348, if he cares to pursue this line of study further than the present outline. The rain which falls upon the earth is partly dissipated by direct evapora-

tion into the atmosphere, another part is taken up by vegetation, and practically all of the balance flows off in the streams. It is apparent, therefore, that if we have reliable measurements of the rain falling upon a given area, and of the amount flowing off in the streams during the same period, the difference between the two will represent the amount either evaporated or taken up by plants, most of which is ultimately also dissipated into the atmosphere and may be included in the general term "evaporation." Our investigations show that evaporation is not directly proportional to the amount of rainfall, although it increases somewhat with increased rainfall. On page 80 of the Report on Water-Supply, formulæ are given by which evaporation can be computed from the rainfall for each month of the year, the mean temperature of the locality being given. This enables us to determine just what amount of rainfall will be equivalent to the combined demands of evaporation and vegetation which we have included in the general term "evaporation." The following table taken from page 336 of the report gives the amounts for the different sections of the State:

RAINFALL NEEDED TO BE JUST EQUAL TO EVAPORATION—INCHES.

	Highlands and Kittatinny Valley	Passaic Water-Shed.	Red Sandstone Plain.	Southern New Jersey.
Winter.....	.97	1.10	1.16	1.27
Spring.....	3.19	3.70	3.91	4.31
Summer.....	9.46	11.12	11.97	13.37
Autumn.....	3.21	3.96	3.90	4.31
Year.....	16.83	19.61	20.94	23.26

Now, if rainfall should be just equal to the amounts given in the table, and we start with the ground full of water on the first of April, the next table shows how much water will drain out of the ground

to the streams during the five growing-months, the amounts being shown month by month in the first column, and the total to the end of the given month in the second column, this table being taken from page 340 of the Report on Water-Supply.

FLOW FROM SPRINGS WHEN RAINFALL EQUALS EVAPORATION.

MONTH.	HIGHLANDS AND KITTIMINNY VALLEY.		PASSAIC WATER-SHED.		RED SANDSTONE PLAIN.		SOUTHERN INTERIOR.	
	Spring Flow.	Depletion.	Spring Flow.	Depletion.	Spring Flow.	Depletion.	Spring Flow.	Depletion.
April.....	1.20	1.20	1.16	1.16	1.43	1.43	1.76	1.76
May.....	.55	1.75	.54	1.70	.64	2.07	1.83	3.14
June.....	.39	2.14	.40	2.10	.45	2.52	1.80	4.44
July.....	.32	2.46	.33	2.43	.35	2.87	1.02	5.46
August.....	.27	2.73	.32	2.75	.30	3.17	.63	6.09

This last is the water held in the voids of the soil and its removal from the soil is not necessarily harmful to vegetation, but, on the contrary, is to a certain extent necessary, and the farmer constructs underdrains in order to get rid of it to a depth of about three feet from the surface, the crops being supplied mainly by the water held in the soil by capillary attraction. The amount of water which may be held in the soil in this way, however, is dependent upon the depth of the free ground-water below the surface, by which we mean the level at which water will stand in an open pit from which no water is drawn. If this ground-water recedes to too low a level, the power of the soil to hold water by capillary attraction is reduced. (See U. S. Department of Agriculture Weather Bureau Bulletin No. 5, page 25.) Of course it must be remembered that the above conditions of rainfall are merely hypothetical, and they never actually occur, but as will be seen by reference to the table, and to the tables of summer rainfall during the dry years which we have already given, the rainfall during that season very frequently falls below the amount needed to equal evaporation. In such cases there is a still further drying of the soil by evaporation, which continues persistently in its work, draw-

ing from the ground-water when rainfall is not sufficient to satisfy its demands. If, on the other hand, rainfall is greater than the amount shown, nature compensates for the increase and prevents the drying out of vegetation by an increased amount of drainage from the soil into the streams, that is, the water in the soil and subsoil acts just like in a sponge, the more nearly it is saturated the larger the amount of water which will run from it. The condition of the ground-water resulting from varied conditions of rainfall will be seen, therefore, to have an important effect upon vegetation and the growth of crops. We may get an idea of how much the ground-water may be drawn down on an average in different sections of the State without injury to vegetation from what happens during the average year. Our measure of the depletion of the ground-water is in each case the depth of rain in inches needed to refill it. In the table on page 341 of the Report on Water-Supply, we show the conditions of the ground-water at the end of each month of the year during an average and ordinary dry and the driest year for each section of the State. Referring to this table, we find the greatest depletion during the growing-months to be as follows: Kittatinny Valley and Highlands, 1.23; Red Sandstone Plain, 2.26; Clay and Marl district, 3.78; Southern Interior, 4.66 inches. These are average figures. The actual amount of depletion ranges from practically nothing on the low grounds to in the neighborhood of twice these amounts on the ridges. Table No. 5 shows month by month during the driest year likely to occur, being the year 1881, the amount of evaporation measured in inches of rainfall, the amount run off in streams, the rainfall, the excess or deficiency of rainfall—meaning by this the amount by which the rainfall exceeds or is less than the combined evaporation and run-off of streams—and, last, the total deficiency of the rainfall to the end of the given month, these last amounts representing the depth of rain in inches which would be necessary to refill the ground with water. It will be noticed that the run-off of the streams is greater for the southern than for the northern sections of the State, the reason for this being that the soil is sandy or gravelly, and contains more water in a given volume than the closer soils of the northern portion of the State, and also gives up the water more freely to the streams. We have selected in each case the best type of each section, but it must be remembered that there are minor differences for different parts of the given section; that is, parts of the Kittatinny Valley and Highlands,

which have a large amount of sand and gravel over their surface, will also show a larger run-off into the streams and a greater lowering of ground-water than is shown by the table. It will also be noticed that, while the rainfall is taken to be the same for all parts of the State, evaporation increases for the different sections because of increased temperature, and the combined effect of greater evaporation and greater drainage into the streams is a very much greater lowering of the ground-water in the southern portions of the State, and this affords a still better explanation of the greater severity of droughts in those portions of the State.

The inspection of the table shows that by the end of August the following amounts of rain would be needed in this driest year to refill the ground-water: Kittatinny Valley and the Highlands, 4.98; Red Sandstone Plain, 7.08; Clay and Marl district and Southern Interior, 9.49 inches.

We believe it to be due, to a considerable extent, to this greater lowering of the ground-water that sandy and gravelly soil, such as that of southern New Jersey, is warmer than more retentive soils. Many phenomena connected with the growth of crops are explained by this tracing of the conditions of rainfall, evaporation, drainage to streams and height of the ground-water for different sections. An important fact to be kept in view is that the result of irrigation is to hold the level of the ground-water at a more nearly constant height, and in consequence of this there will be a somewhat increased discharge of water from the subsoil to the streams. We have, consequently, to supply, not merely the water demanded by the plants, but this additional run-off from the soil. This increased porosity of sandy soils and readier discharge therefrom is not, however, to be regarded as an unfavorable condition to irrigation. On the contrary, it insures good drainage and prevents the presence of stagnant water in the ground from too much watering, which is sometimes so hurtful to irrigated crops.

TABLE NO. 5.

Rainfall, Evaporation, Run-Off and Condition of Ground-Water During Driest Year, Measured in Inches of Rainfall.

Kittatinny Valley and Highlands.

	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	Year.
Evaporation	.74	.57	.69	.76	.83	2.13	3.07	2.91	2.58	1.61	1.10	.76	17.75
Run-off	3.31	3.09	4.07	3.07	1.10	.60	.65	.27	.17	.14	.15	.20	16.82
Rainfall	4.05	3.66	4.76	3.83	.61	2.71	3.87	.96	1.18	.94	3.04	2.02	31.63
Surplus (+) or deficit (-) .....	.....	.....	.....	.....	-1.32	-.02	+.15	-2.22	-1.57	-.81	+1.79	+1.06	-2.94
Total deficit to end of month .....	.....	.....	.....	.....	1.32	1.34	1.19	3.41	4.98	5.79	4.00	2.94	.....

Red Sandstone Plain.

Evaporation.....	.87	.67	.82	.90	.98	2.53	3.64	3.45	3.06	1.91	1.30	1.90	21.03
Run-off.....	3.18	2.99	3.94	2.93	1.30	.58	.47	.24	.16	.15	.16	.16	16.25
Rainfall	4.05	3.66	4.76	3.83	.61	2.71	3.87	.96	1.18	.94	3.04	2.02	31.63
Surplus (+) or deficit (-) .....	.....	.....	.....	.....	-1.67	-.40	-.24	-2.73	-2.04	-1.12	+1.59	+.96	-5.66
Total deficit to end of month .....	.....	.....	.....	.....	1.67	2.07	2.31	5.04	7.08	8.20	6.61	5.65	.....

Clay and Marl District and Southern Interior.

Evaporation.....	.95	.73	.89	.98	1.06	2.75	3.96	3.75	3.33	2.07	1.41	.97	22.85
Run-off.....	3.10	2.93	3.87	2.86	1.46	.91	.84	.46	.30	.30	.30	.30	17.62
Rainfall	4.05	3.66	4.76	3.83	.61	2.71	3.87	.96	1.18	.94	3.04	2.02	31.63
Surplus (+) or deficit (-) .....	.....	.....	.....	.....	-1.91	-.93	-.93	-3.25	-2.45	-1.43	+1.33	+.75	-8.84
Total deficit to end of month .....	.....	.....	.....	.....	1.91	2.86	3.79	7.04	9.49	10.92	9.59	8.84	.....

NOTE.—The quantities representing the total deficit at the end of a given month show how much rain or water of irrigation would be needed to refill the ground.

THE AMOUNT OF WATER REQUIRED.

Knowing that our average rainfall represents conditions very favorable to good crops, this affords a simple standard by which we can determine how much water will be necessary for irrigation in the various sections of the State, for we may safely assume that it will be the difference between the average for each section and the lowest rainfall for the various periods, as shown by Table No. 2. In this table we find the lowest amount of rain from April to August is 9.33 inches, and by seasons the lowest for the spring is 5.23 inches, and for summer 4.62 inches. For the driest month the rainfall is only a fraction of an inch, and we may safely assume that we will have to provide a quantity equal to 4 inches of rainfall for at least one month during certain years. This gives us the following estimate of water required :

QUANTITY OF WATER REQUIRED FOR IRRIGATION, MEASURED IN INCHES
OF RAINFALL.

	Driest April to August.	Driest Summer.	Driest Month.
Kittatinny Valley and Highlands.....	10.42	7.73	4.00
Red Sandstone Plain.....	11.20	8.24	4.00
Clay and Marl Regions.....	11.78	8.60	4.00
Southern Interior.....	12.34	8.95	4.00

We find, therefore, for the whole growing season, we shall have to provide in southern New Jersey practically the equivalent of 12 inches in depth of rainfall, and that our works must be so proportioned as to be able to deliver, during one month, the equivalent of 4 inches. The latter may be taken as the required capacity of the canals and ditches, or other means of conveying the water, while the quantities in the first column represent the total amount of water which must be provided. For very much of the time this will be more than we shall actually need ; but irrigation works, to be satis-

factory and successful, should be capable of meeting the driest possible conditions. At 4 inches per month, the duty of water, as it is called, or the required rate at which the water must be furnished, is .55 cubic foot per second for each hundred acres. As it has been found in California, with a temperature considerably higher than ours and a lighter rainfall, that the requirements are met by 1 cubic foot per second for each 200 acres, which is very close to our above estimate, we shall adopt this as the proper average duty for southern New Jersey. We have found that the streams of southern New Jersey may be depended upon, in the driest month, to discharge .25 cubic feet per second for each square mile of catchment, and it follows that, without storing water, we may draw from these streams enough water to irrigate 50 acres of land for each square mile of gathering-ground on the stream.

STORAGE OF WATER.

In cases where it is practicable to construct storage reservoirs to utilize the yield of the stream during the wet season for irrigation purposes, a much larger area can be watered by a given stream. Our investigations of yield of southern New Jersey streams show that we can always utilize 12 inches of rainfall, even in the driest year, but in order to make this amount available during the growing-months from April to August, we shall have to provide storage at the rate of 122 million gallons for each square mile of catchment. As we need just 12 inches depth of water for irrigation purposes, it follows that with this amount of storage a stream would furnish enough water to irrigate an area equal to its catchment. The cost of storing water varies considerably with the locality, and is greater for small amounts, and less for works on a large scale, but for our present purposes we may take the cost to be \$150 per million gallons, which would make the cost of the above 122 million gallons \$18,300, which would be a charge on 640 acres irrigated amounting to \$28.60 per acre, which is evidently too high a cost for storage alone. To utilize 6 inches of rainfall on the catchment we shall need 36 million gallons storage for each square mile, costing \$5,400, and this would serve to irrigate one-half a square mile, or 320 acres, making the cost \$16.88 per acre for storage. To utilize 3 inches of rainfall on the catchment during the growing-months we shall need 17 million gallons of storage for each square mile of catchment, costing \$25.50, and this would irrigate

160 acres, making the cost about \$16 per acre, and it will be seen that we must be prepared to expend about this amount if storage is attempted at all. The question must be decided, however, for each case, consequently in making up our estimates of the ultimate capacity of various streams for irrigation purposes, we have taken an area equal to the catchment of the stream.

SEEPAGE, OR RETURN-WATER.

We have already seen that a considerable part of the rainfall flows off in streams, and in our table of flow from springs we find that without any additions from rainfall the earth will yield up as seepage during the five growing-months a quantity of water equal to from 2.73 to 6.09 inches of rainfall in various parts of the State, the latter amount being that given up by the sandy soils of southern New Jersey. The rate at which this water is discharged from the earth depends on the amount held in the ground or the height at which the ground-water is maintained, as shown by the table. Since the purpose of irrigation is to maintain ground-water at a higher elevation than it would otherwise stand, it follows that the amount of this seepage or yield from springs to the streams would be increased thereby. We may arrive at the amount of this water from the data contained in the Report on Water-Supply. During the average year we find from page 341 of that report that the ground-water is drawn upon or depleted from April to August, an average of 2.32 inches on the coast streams of southern New Jersey, whereas during the driest year it is depleted to an average of 5.82 inches. Now, if we assume that by irrigation the ground-water will be maintained in the condition of an average year, the flow of seepage or spring-water will be increased from that due to 5.82 inches depletion to the amount due to only 2.32 inches depletion. Following page 126 of the same report there is given a diagram showing what this flow would be on the Great Egg Harbor and Batsto catchments for any given depletion. By means of this diagram we find for 2.32 inches depletion a yield of 1.40 inches per month, and for 5.82 inches depletion a yield of 0.80 inches per month. Therefore, we have an excess amounting to 0.60 inches per month of seepage-water due to irrigation on this assumption. We may check this by taking the table on page 266 of the same report, showing the yield of these southern streams for the aver-

age and the driest year. From April to August this yield amounts to 8.37 inches for the average, and 5 inches for the driest year, showing an excess for the average of 3.37 inches during the five months, or 0.67 inches per month, agreeing sufficiently well with our previous estimate. It therefore appears that if we used for irrigation an amount of water equal to 12 inches of rainfall, 3 inches will be returned as seepage-water, or 25 per cent. of the total amount diverted from the stream. This estimate, arrived at from observations of the yield of the streams, agrees well with results obtained by some actual gauging of streams in irrigated sections of Colorado. (See Bulletin 33, Colorado Experiment Station.)

The actual amount of seepage, or return-water, will probably exceed this estimate somewhat, from the fact that ground-water will be usually held at a little higher level, but we are disposed to think that very much increase in height would be rather detrimental to crops than otherwise. There is a tendency, where irrigation is applied, to use too much water. As we have previously stated, the drawing down of ground-water, to a certain extent, is necessary for the proper development and perfection of the crop. Good drainage is very essential to successful irrigation. The presence of free ground-water about the roots of the plants prevents the proper aëration and consequent oxidation of the elements of the soil necessary for plant-growth, and it also produces a cold and late soil.

The amount of this seepage, or return-water, should have an important bearing on the question of damages for the diversion of water in all cases where such seepage water returns to the stream from which the irrigation-water has been diverted. It will almost invariably return to the same stream when the irrigation district lies within the catchment of that stream.

COST OF IRRIGATION.

The following figures, given in the Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, pertain to the western part of the United States, where irrigation is successfully practiced.

	Average for United States per acre.	Average for California per acre.	Average for Utah per acre.
Cost of irrigation works.....	\$8.15	\$12.95	\$10.55
Value of water rights.....	26.00	39.28	26.84
Annual cost.....	1.07	1.60	.91
Cost of bringing land under cultivation...	12.12	17.48	14.85

The first figures given above represent the cost of bringing the water to the land, while the next below represent the value of such water after it has been secured, and subtracting the first from the second we find an average profit by irrigation of \$17.85 per acre from enhanced value of land taken together with the water rights. The annual cost is either that of maintaining the works, or is the annual rental paid for the use of water when furnished by a corporation, while the cost of bringing land under cultivation includes clearing and leveling up to receive water. In California irrigation is applied to orchards, vineyards, small fruits and other more valuable crops, so that the figures for that State are a better guide to us in New Jersey than the average of the whole. In Table No. 3 we showed that irrigation might easily yield an improvement of about \$10 per acre in the potato crop, but we should here remark that of late years the hay crop in New Jersey has been a very valuable one, and the very moderate improvement of one ton per acre in this crop would yield a larger return than \$10 annually. Indeed, the raising of hay and forage crops by this means would be an important advantage to portions of southern New Jersey, where they are grown with much difficulty. Taking 6 per cent. on the above figures of first cost of works for California, we have for interest 78 cents, which, added to the annual cost, makes \$2.38 annual charge per acre, to which we must add the extra labor of applying the water, or of irrigation farming over dry farming. The latter cost will depend largely upon the crop, but may be averaged at about \$6 a season, making a total increased cost chargeable to irrigation of \$8.38 on the California basis.

As the conditions in southern New Jersey are generally favorable to low cost of irrigation by means of canals and ditches, on account of the character of the soil and the gentle and uniform slopes, there is no reason why the average cost should exceed the above estimate, and in many favorable localities it will be considerably less. Where there are valuable water-powers this will add appreciably to the cost of irrigation, and will make it almost impossible to carry out a profitable scheme, except it be done on a large scale. For illustration, if Maurice river should be fully utilized for irrigation, it would water, without storage, 19,300 acres, and with storage, about 250,000 acres. The cost of extinguishing the rights of water-power owners would probably amount to not less than \$20 per acre on the smaller area, and about \$1.50 per acre on the larger area. This difficulty would

generally be much less serious than in this case, however, although it would frequently be encountered. It must be remembered in considering this question that we are very conservative in our estimates as to the area which may be watered by these streams, from the fact that we have thought it well for the present not to take in consideration the large amount of the seepage-water returned to the stream. Those who have followed our discussion of the water needed, have observed that a considerable part of it is needed to make good the flow from springs which drain the water out of the soil. This water, of course, returns to the streams, and may be used over again, although we have not taken it into account.

SOME AREAS CAPABLE OF BEING WATERED BY GRAVITY.

The following areas in southern New Jersey are capable of being brought under water by ditches and canals and supplied by gravity :

Metedeconk river, in Ocean county, is capable of watering 3,700 acres without and 47,000 acres with storage. All of this land favorably located and having a soil well adapted to the purpose, may easily be found to the south and east of Burrsville. The water rights interfered with in this case would not be so important as to be a serious obstacle.

Toms river, in Ocean county, would water 8,200 acres without and 105,000 acres with storage. This water could be applied to various strips of land along the stream and its branches, although, on the whole, the topographical conditions are less favorable than on the Metedeconk.

The waters of Cedar creek and Forked river will suffice to irrigate 3,500 acres without and 45,000 acres with storage. They could be applied to good lands in sufficient amount and favorably located between Waretown and Barnegat Park along the bay shore.

Mill creek, West creek and Tuckerton creek, in Ocean and Burlington counties, will water 2,500 acres without and 32,000 acres with storage. These also could be used on good lands favorably situated near Manahawken, West Creek and Tuckerton. Wading river is capable of watering 9,000 acres without and 115,000 acres with storage. Lands well adapted for the purpose are found about New Gretna, Harrisville and Green Bank, with some smaller areas along the upper stream and its branches.

Mullica river, above Batsto, will furnish sufficient water to irrigate 11,000 acres without and 140,000 acres with storage. The water-shed of this stream is almost level in a direction almost transverse to the course of the streams, and slopes with the streams at the rate of about five feet to the mile. A large area of sandy land could easily be brought under water lying between Batsto, Hammonton and Atsion. This land is, at present, mainly waste land.

Great Egg Harbor river will furnish water for 15,000 acres without and 192,000 acres with storage. The water could be used on a belt of land lying along the stream between New Germany and Mays Landing, most of which is wild land, also on a strip along each bank below Mays Landing, that along the west bank between the highway from Mays Landing to Tuckahoe, and the salt marsh being quite favorable for the purpose, and including some areas now under cultivation. An important water-power at Mays Landing would be affected by any extensive irrigation works, but along the west bank, between Mays Landing and Tuckahoe, considerable development could be made by utilizing South river and Stephens creek without affecting any valuable water-power. The same is true of Babcock's creek at Mays Landing.

Tuckahoe river is sufficient to water 2,500 acres without and 32,000 acres with storage, and land well adapted for the purpose, a considerable part being already under cultivation, is found along both banks of the river between Hunter's mill and Tuckahoe.

The streams of Cape May county are not adapted for gravity irrigation except in a limited way. Manumuskin and Manantico creeks would together furnish water for 3,500 acres without and 44,000 acres with storage. They could easily be made to water all of the land between the West Jersey railroad and Maurice river, extending from Millville to Porth Elizabeth, and Manantico creek especially affords an opportunity for an irrigation development on a considerable scale without interfering with any water rights, the mills on the stream now all being abandoned.

Maurice river, above Mays Landing, is capable of watering about 11,000 acres without and 170,000 acres with storage. The water would have to be applied to lands lying along both banks of the river and its branches, and generally not more than 30 feet higher than the stream. Not much of this land is now under cultivation, although there is some on the west branch between Union Grove and Bradway.

The above-mentioned streams, being the Atlantic coast streams of southern New Jersey, offer good facilities for irrigation by gravity, but the streams on the Delaware slope of the State do not present such favorable conditions topographically. For the most part these streams run at low level through ravines with flat bottoms and rather steep banks, so that water could only be brought out on the neighboring lands by means of low canals from points so high on the streams that the drainage area is small and insufficient to furnish any large amount of water. This country along the lower Delaware, however, contains some fertile lands and it is the region of the lightest rainfall and severest droughts in the State, consequently probably nowhere would irrigation be more profitable.

Cohansey creek above Bridgeton would water 2,250 acres without and 28,000 acres with storage, but the topographical conditions are very unfavorable for gravity systems. We shall see later how the waters of the creek may be used advantageously by pumping. Salem creek at Sharptown, if diverted at about fifty feet elevation, could be made to water 1,000 acres without and 14,000 acres with storage. This water could be used profitably on fertile lands now under cultivation in Upper Penns Neck and the west part of Mannington township.

Alloways, Oldmans, Raccoon, Timber and Cooper's creeks are open to the objections which we have pointed out as peculiar to streams of the Delaware slope, and are not well adapted for gravity systems of irrigation.

Rancocas creek, above the forks, will water 15,000 acres without and 192,000 acres with storage, but there is a considerable amount of valuable water-power which would be affected. The water could be applied to land distributed along the stream in Pemberton, Lumberton, Eastampton and Southampton townships, Burlington county; most of these lands being now under cultivation.

Crosswicks creek is not well adapted to a gravity system of irrigation.

Some 5,000 acres of level gravity lands, east and northeast of Trenton, and under 60 feet elevation, could be watered by the headwaters of Assanpink creek.

This brief review of the possibilities of gravity irrigation in southern New Jersey shows that 75,000 acres can readily be watered without the use of storage reservoirs, and over 900,000 acres if the streams are fully utilized by storage. It is seen, however, that the cost of such storage would scarcely be warranted, but it is considered that the

watering of 250,000 acres of the areas that have been indicated is entirely practicable. Most of this land is on the Atlantic slope, and very little of it is now under cultivation. Exclusive of storage charges, it could generally be irrigated at a cost within the figures already given for California, or say within an annual charge of \$8 per acre. If this area could be successfully brought under cultivation by this means, it would add 10 per cent. to the total cultivated area of the State, and probably from 20 to 25 per cent. to the value of its agricultural products. Several of the districts mentioned offer excellent opportunities for a beginning on comparatively a small scale, and in such a manner that, ultimately, the development could be extended to the full capacity of the stream. The fact must be recognized that the benefits to be derived from irrigation must first be demonstrated by works on a limited scale, although the highest efficiency and the largest amount of profit will be realized by a large scale of development. Generally, the soil of these tracts and the configuration of the surface are very favorable to the purpose, and a large part of the land could be acquired at a low cost. The conditions are peculiarly favorable for market-gardening and the raising of fruit.

In the northern part of the State the need of irrigation is sometimes felt quite severely on the Red Sandstone Plain, but to a much less extent in the Kittatinny Valley and Highlands. The water could almost always be applied on this part of the State by gravity, but water rights are more valuable here, so that it is scarcely probable that irrigation will be extensively adopted for general farming, although it may be for special crops.

For the present no mention is made of those specific cases suitable for gravity systems of irrigation in northern New Jersey. There are, however, quite a number of cases where irrigation could be used profitably in these sections of the State. Considerable areas, such as Pompton Plains and other fertile portions of the Passaic Valley, offer facilities for such improvement.

IRRIGATION BY PUMPING.

While irrigation by gravity, through canals and ditches, is a simple and well-tried method, and one which usually gives a low operating cost, there are many cases in New Jersey where the water could be advantageously pumped. There are large fertile areas in Salem and

Gloucester counties which cannot be watered by gravity, but which are traversed by numerous creeks, where an abundant supply of water can be obtained at all times. The whole area is also bordered by the Delaware river, the water of which, down to the head of the bay, is usually fresh enough to be used for this purpose. A considerable area of good land along the east shore of Delaware bay and south of Cohansey creek is similarly situated. Then, again, in many cases the cost of extinguishing water rights would be eliminated by pumping from the lower parts of the streams, and the saving thus effected might fully compensate for the cost of pumping, not to speak of the saving in construction of long main canals. Pumping could be applied in the districts which we have mentioned, either to raise the water into irrigation canals and ditches, to be distributed by the ordinary method, in which case pumping would be done inexpensively by centrifugal pumps; or force pumps could be used and the water distributed under pressure through a network of pipes to be laid over the district to be irrigated, the water being applied by means of hose from a number of conveniently-situated hose-plugs. At first sight this seems an expensive method, but it bears the test of careful estimate, and has very great advantages where it is important to economize water or to distribute it readily and conveniently, as would be the case where irrigation is employed in market-gardening and in orchards. For the purpose of an estimate an area of 640 acres is taken, or say 32 garden plots of 20 acres each, the water being pumped from a stream and distributed by means of pipes, as we have suggested. It is found that for such a tract of land a plant of the best character could be installed for \$45,000, or about \$70 per acre. It is also estimated that allowing on this sum 6 per cent. interest and 3 per cent. for depreciation, all expenses of operation, including the watering during a season of 100 days, would not exceed \$15 per acre. It is believed that good returns could be had from this outlay in any of the districts which we have mentioned as favorable to the application of this system. The cost of this system per acre would increase with smaller plots than 640 acres, and would decrease if applied on a larger scale. It is probable, however, that by the use of small pumps operated by gasoline engines, which could be operated without the constant attendance of an engineer, the system could be profitably applied without much increase of cost to a single ordinary farm. For smaller plants, however, such as are likely to be adopted experiment-

ally during the early attempts at irrigation in the State, it is probable that a windmill pumping to a tank, either from a well or stream, the water to be distributed from the tank by pipes, would be the most practicable system.

The consideration of this question of limited or experimental plants is considered in a later portion of this report.

AREAS CAPABLE OF IRRIGATION BY PUMPING.

The following areas are conspicuously adapted for such an extended system of irrigation by pumping as we have estimated upon, while they are not favorably situated to be watered by gravity. In Cumberland county, south of Cohansey creek and west of the Cumberland and Maurice River railroad, near Fairton and Cedarville, some 16,000 acres could be thus irrigated. The water for this purpose could be obtained from Cohansey creek. The soil is good, and most of this district is now under cultivation. Some five or six hundred acres between Cohansey and Stow creeks, in the same county, could be watered partially by pumping and partially by gravity. The whole of the western portion of Salem county, extending six miles or more back from the Delaware river, and including some 80,000 acres of fertile land, most of which is now under cultivation, is well adapted for irrigation by this method. In Gloucester county, about 40,000 acres along the Delaware and its branches could be watered. In Camden county about 12,000 acres, and in Burlington county 25,000 acres are suitable for this treatment. There is also some land between Red Bank and Colt's Neck, in Monmouth county, which could be watered from Swimming river. A total of at least 175,000 acres of good land, mostly under cultivation, in the counties named, is adapted for irrigation by pumping either into irrigation canals in the more usual way or into pressure pipes, as has been suggested. Most of this land lies convenient to tidal creeks and rivers whose waters are fresh or only slightly brackish. The waters of many of these creeks also carry a very considerable amount of rich sediment, and would undoubtedly have a marked fertilizing tendency.

IRRIGATION BY WELLS.

As is now well known, southern New Jersey affords an excellent field for obtaining a water-supply from tube wells. An examination of the returns of a considerable number of wells indicates that it is fair to expect from a six-inch well from 100 to 200 feet deep, a yield of 25,000 gallons daily, or sufficient to irrigate 10 acres of land. This is purposely conservative, and we are well aware that there are a number of wells which would be ample for 20 acres. Of course this method of irrigation means that we must pump by windmill or other power, and in order to use the water economically it should be applied by pipe distribution under pressure. This well-water may have the disadvantage of a lower temperature, which could be partially remedied by storing in a tank, and may not have all the fertilizing properties of stream-water, but the method allows the entire plant to be confined to the limits of a small farm without risk of damage to water rights or otherwise. There are also many cases where a gang of small driven wells of moderate depth, say 15 or 20 feet, would answer the purpose better than tube wells. It is impossible to make any estimate of how much land may be irrigated in this way, but the aggregate may be large.

WARPING.

This process, which properly comes under the head of irrigation, is applicable to tidal meadows which have been reclaimed, and is a process not unknown in Cumberland and Salem counties, where it has been practiced to a certain extent for many years. It is a well-known fact that tidal meadows which have been embanked and improved generally shrink and settle to a level considerably below the level of high tide. Some of the older embanked meadows in the State range from 2 feet to $4\frac{1}{2}$ feet lower than high-tide level. This gives an opportunity for the application of warping, which is letting the waters flow in upon the embanked land to deposit their sediment. The system has been carried to a high degree of perfection in some portions of England, where the works are of a substantial character and the water is controlled by permanent sluices. In our own State the process is often effected by simply cutting the banks, which does

not leave the farmer a proper control of the water. The purpose to be kept in view in this method of irrigation is to secure the best and largest part of the sediment contained in the water as a deposit upon the land, and the flowing and running off of the water must be so controlled that the volume of mud deposit has an opportunity to dry between tides. The result, when properly conducted, is to secure to the land under treatment a new soil, and the accumulation of sediment is much more rapid than would commonly be supposed. Ordinarily one year will suffice to entirely renew the soil of such a tract. The area of tidal meadow which has been reclaimed in Gloucester, Salem and Cumberland counties amounts to about 26,000 acres. In the past the cultivation of these tracts has been very profitable, but during recent years there has been a tendency to neglect these somewhat, a fact which is partly due to the low prices of agricultural products. But, while the very large returns of the past may not be again obtained, it is worth while to consider whether, even under present conditions, a good profit is not possible in cultivating these meadows, and whether a careful application of the warping process would not be a means to this end.

WATER MEADOWS.

While the application of irrigation will probably be most sought by the market-gardeners and producers of small fruits, it seems worth while, in view of the general scarcity of hay and pasturage in southern New Jersey, to call attention to the possibilities of irrigation in producing hay and forage crops. The application of irrigation to water meadows in England is well known, and the results seem to have been highly satisfactory. The method of applying the water does not differ materially from ditch and bedwork irrigation for other purposes, but the water is mainly applied through the winter months in England, although to a less extent throughout the year. It is so applied as to protect the grass from the effects of early and late frosts, thus giving it an opportunity to start much earlier in the spring. It has been found possible to produce on each acre one month's grazing for from 30 to 40 head of sheep in the spring, and after that two tons of hay, or more, have been cut, or when used for grazing alone the same number of sheep have been fed throughout the season. This is a sufficient indication of the possibilities of irrigation for this

purpose, and there seems to be no good reason to doubt that on the lower-lying lands of southern New Jersey as good results as this could be obtained. The expense of watering such meadows is comparatively light, but the amount of water used is rather large. It is used so largely during the months when it is not employed for irrigating ordinary crops, however, that this would not be any great objection, and it could well form a part of a general system of irrigation.

TOTAL AREA IRRIGABLE.

If only the available water-supply is considered, it is found that even in the driest year which has been experienced, enough water has run to waste in the streams to furnish an ample supply to irrigate the entire area of the State. Considering only the areas in southern New Jersey which we have pointed out as peculiarly well adapted to development at a reasonable cost, we find that, neglecting what may be watered by wells, fully 325,000 acres may be brought under water, and this alone, if well managed, would probably increase the value of the agricultural products of the State not less than 30 per cent.

SUGGESTIONS FOR SMALL PLANTS.

The estimate of duty of one cubic foot per second for each 200 acres amounts to 3,236 gallons daily during the month of maximum requirement. With a pipe distribution the economy of water would be such that this would probably be reduced to 2,500 gallons daily per acre. The maximum monthly requirement was estimated at four inches per month, and if it is assumed that by pipe distribution this may be reduced to three inches, and let this be divided into four waterings, it will require three-fourths of an inch for each watering, which is practically 20,000 gallons per acre. Assuming that we wish to water an area of ten acres, requiring 200,000 gallons for each watering, and estimating in all 16 waterings for the season, for the driest month we shall need one watering each week. If this water is applied in six days, it will need all of the time of one man during this month, and 96 days of his time during the season of maximum requirement. If the plant is arranged so that the watering may be accomplished in three days, the driest season will require 48 days in all for the watering and 66,000 gallons daily. This is probably a

good basis on which to work, because there will be so many years when only a fraction of this amount of time will be consumed, and indeed the maximum requirement will only occur at long intervals. At ten hours daily we must be able to distribute 6,600 gallons hourly from any hose-plug in the plant, and this determines the capacity of our pipes and pumping engines. It is evident that for a plant of this size, if we depend on windmills, we should have tanks at hand to store at least one day's requirement, or 66,000 gallons. Assuming that our ten acres is square, with a well driven at the center and pumping by windmills to tanks, we estimate that the entire cost of installing the plant will be \$4,500, or about \$450 per acre. Of course, the operating expenses of such a plant will be light, as nothing is required for fuel and the operation of the pumps. This provides for an ample plant, but if one chooses to take some chances on the extreme dry years, a lighter plant will suffice, and the cost may be cut down even as low as \$2,500, and still give works of fair efficiency which may once in 25 years during the extremely dry season require all of one man's time to do the watering. In this plant we have adopted four-inch galvanized, lap-welded wrought-iron pipe for the distribution, and so disposed that the maximum distance from a hose-plug to any part of the tract is 110 feet. About 100 feet of two-inch hose would, consequently, be required.

If for the windmill, a gasoline vapor engine of sufficient capacity to deliver 6,600 gallons hourly is substituted, the storage tanks will not be needed, provided that the well is of sufficient capacity to yield this amount of water. Of course this will deliver the water at a lower temperature. The cost of such a plant will be about \$1,000 less, or \$3,500. This would probably also be cut to \$2,500 by adopting a lighter plant, say one capable of delivering 3,300 gallons hourly. Such a lighter plant would have three-inch pipe instead of four-inch pipe, as well as a lighter engine, and since during the driest weather its deficiency could be made good by simply taking more time to do the watering, it is probable that this reduction would be a wise economy. In case this plant should draw from a stream instead of a well the cost would not be materially different in case the stream was not more distant than about 500 feet from the tract to be watered. It is to be preferred to the wind engine because of its greater reliability. The cost of operation is light, as the engine needs very little attendance; the cost of fuel for the lighter engine amounting to about

50 cents daily. There are also probably a number of localities near some existing or abandoned mill-site where water-power could be utilized cheaply for pumping, thus offering favorable conditions for a test of irrigation.

If we wish to adopt a gravity system for our test it will usually be advisable to construct works sufficient to bring about 100 acres under water, and even to do this it will generally be economy to select a site favorable to further extension and begin our works of sufficient size for such extension ; thus a ditch 7 feet wide on top, 2 feet at bottom and $2\frac{1}{2}$ feet deep can be constructed in many parts of southern New Jersey at a cost not exceeding 12 cents per foot. Such a ditch, with a fall of 1 foot in 2,500, will deliver 20 cubic feet a second, or enough water to supply 4,000 acres of land. If a favorable location, such as several we have in mind, is selected, where either there already exists an abandoned mill-dam which can be repaired, or where the site is favorable to a small dam at a low cost, a mile of canal and a dam may be constructed at a cost not exceeding \$1,100, and 100 acres could be brought under water. The cost would, therefore, be \$11 per acre, which is not excessive. This will enable a thoroughly satisfactory trial to be made, and such works could be gradually extended until the entire 4,000 acres are irrigated. When so extended the entire cost for dam, canals and main ditches would not exceed about \$5 per acre. The economy of large-scale works by the gravity system is very marked, but it will be seen that if a start is made under such conditions as we have supposed, the cost of a small development need not be excessive, while, if successful, the prospects are excellent for a large profit in the ultimate extension of the works. It is shown by the figures quoted from Mr. Newell's report that, taking the average over the whole United States, the rental value of this water thus brought to the land would amount to \$1.07 per acre, while in California it amounts to \$1.60. Many instances might be quoted where a much higher rental has been paid, but these figures are sufficient to suggest the handsome return possible from such a plant. It is impossible to enumerate at present all the points at which such a development could be taken under favorable conditions, but among others we have in mind Hunter's mill-pond, to be used for the lands along the north bank of the Tuckahoe river ; Cumberland pond, on Manumuskin creek, to be applied along the west bank of the creek ; the pond at Bamber and Cedar Creek, in Ocean county ; and the mill-

pond on Kettle creek at Silverton, where there is probably not more than enough water, however, for about 400 acres. Conditions are generally less favorable for such a plant on the Delaware slope, for reasons which we have already pointed out; still they may be found on examination.

THE USE OF IRRIGATION IN NEW JERSEY; THE METHODS USED AND THE RESULTS SECURED.

More or less complete data on the above points were secured from five irrigation plants, three located in Gloucester, one in Cumberland and one in Hunterdon county. Three of these have been in operation from two to twelve years, have given eminent satisfaction and illustrate nicely the practicability and usefulness of irrigation for small fruits and vegetables, especially on limited areas.

No. 1. John Repp, Glassboro, Gloucester County.

Mr. Repp's fruit farm of 100 acres is located near Glassboro, Gloucester county, upon which is grown a great variety of fruit—peaches, apples, berries, grapes, etc.—though a considerable portion of the land is devoted to market-gardening while being prepared for fruit crops. Mr. Repp has irrigated from $2\frac{1}{2}$ to 3 acres since 1884, and is about to increase largely his operations in this direction. He has found that in two years out of three there will be dry periods, when it will pay to irrigate the crops with which he has experimented.

CHARACTER OF SOIL AND METHOD OF MANURING.

The land that has been irrigated during the last twelve years by Mr. Repp is a sandy loam, overlaid by a clayey subsoil. It has been heavily manured with New York stable manure and fertilizer before being irrigated, and has been manured every year since in the same way until 1892. Since 1892 chemical fertilizers have been used alone before plating. He still uses the manure in the fall as a mulch.

THE IRRIGATION PLANT.

The accompanying outline shows the position of the area, $5\frac{1}{2}$ acres, upon which irrigation has been practiced, and the location of the reservoir, pump and pipes in reference thereto.

A shows the shape of the pond, which covers about one-half an acre. The water backs up into the swampy land where the springs are located, and is about four feet deep near the dam.

B, the pipe that carries the water to the pump, opens near the surface of the pond, several feet from the bank. The water enters the pipe through a strainer.

C represents the position of the engine-house, or pumping station. This is a small, substantial structure, built to cover and protect the steam pump and boiler, which fill the available space therein.

At *D D'* is shown the position of the underground main pipe, 1½ inches inside diameter, leading from the pump to the field to be irrigated, which is divided into two nearly equal parts by this main pipe. On one side is 3 acres, on the other 2½ acres. The side pipes *a a a*, one-quarter inch inside diameter, are laid underground at a distance of 10 feet. These pipes are furnished with faucets *a' a' a'* for attaching rubber hose.

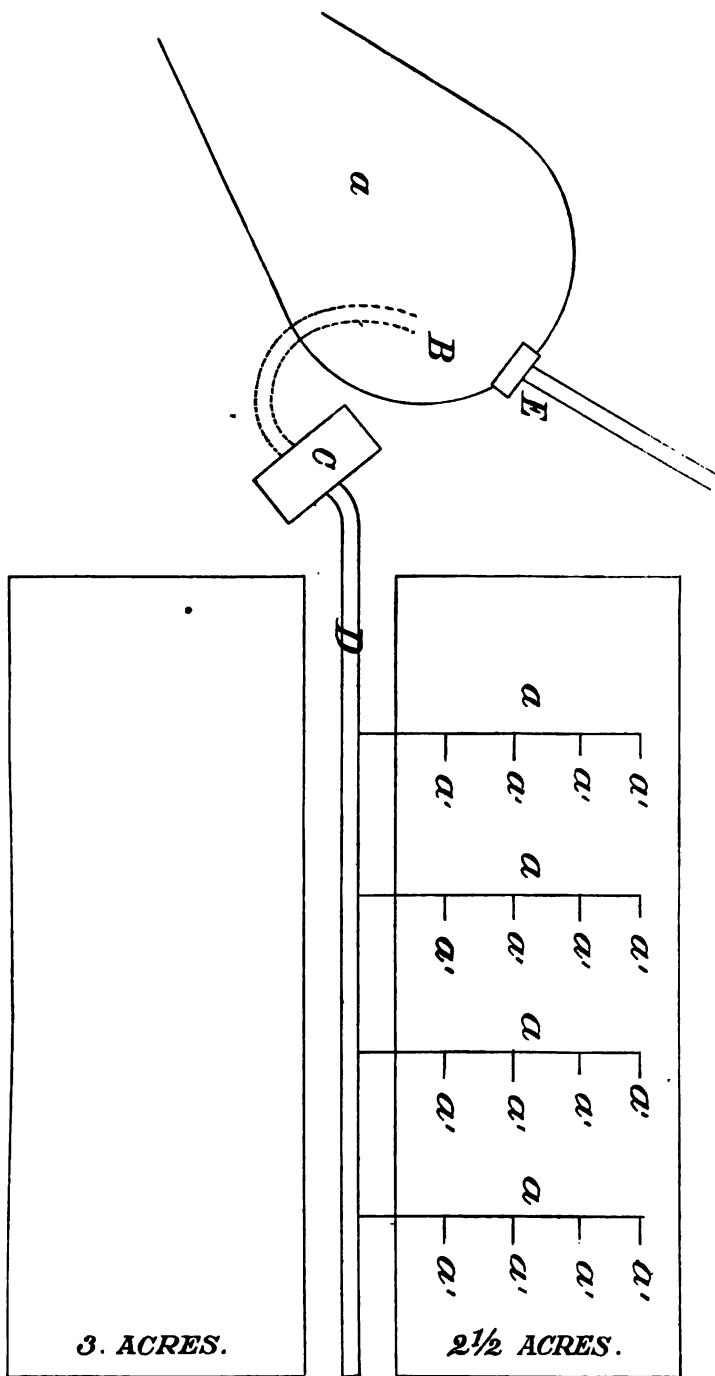
IRRIGATION OF STRAWBERRIES.

Mr. Repp describes his actual operations in watering or irrigating a field of strawberries as follows:

"Growing strawberries with irrigation is something to which I gave a great deal of thought long before I put my thoughts into practice. When I first commenced to grow strawberries, after I had expended a great deal of hard labor and used large quantities of fertilizers to get a crop, about the time I commenced to pick my berries a drought would set in and a few hot days would blast all of my hopes, as well as my berries. If I got \$100 per acre clear of expenses I thought I was doing well.

"About ten years ago, I built a dam across a small stream that is fed by springs, that runs through my place, inclosing about one-half an acre of water, three to four feet deep. The land I wanted to irrigate is from four to ten feet above the water. I first thought I would get a windmill and pump the water into a reservoir, but I found it would take 800 barrels of water to cover one acre an inch deep; as I wanted to grow about three acres, and in time of drought it would be necessary to put on not less than one inch of water twice a week, this, in my judgment, rendered the storage scheme too expensive and so I put in a steam pump, which, with an eight-horse-power boiler, will raise 800 to 1,000 barrels a day. The cost of the entire plant, including pipe and hose, was \$600.

PLATE I.



"I laid off my land in two blocks, $2\frac{1}{2}$ acres in one and 3 acres in the other. Between the blocks I laid a $1\frac{1}{4}$ -inch pipe under the ground. I have one of the blocks in berries each year. In planting, I get ground fine and level, mark out with hand-marker every other row twenty inches, every other twenty-eight inches; plant one foot in row; cultivate and hoe. In hoeing, the man walks in the wide row, and by so doing leaves the ground a little lower between the narrow rows. In August, I stop cultivating between the narrow rows, let them fill up with runners, and keep the wide rows cultivated till fall. Before winter sets in, cover the beds with horse manure, about a carload to the acre. In early spring, rake the manure in wide rows, cover the manure with salt hay, using one ton per acre. The 1st of May, put on 800 pounds per acre of a good fertilizer.

"As soon as it gets dry, start the pump. I run the rows at right angles to the main pipe, laying three-fourths-inch pipe ten feet apart, parallel with the rows, have spigots about sixty feet apart on the small pipe, and connect with three-fourths-inch hose fifty feet long. A man changes the hose from row to row, running the water down the row. The longest period that I have been obliged to use the pump in any one year was nineteen days. My expenses for two men, fuel and wear of plant are about \$3.50 per day."

COST OF IRRIGATION.

The first cost of a plant similar to the one operated by Mr. Repp would be considerably less now than in 1884, the year when he started. Windmills have been improved since that time, and now less expensive gasoline engines are also entirely practicable for this work. Mr. Repp estimates the original cost of his entire plant at \$600, the chief items of which are—

Worthington steam pump.....	\$190.00
Steam boiler.....	150.00
400 feet rubber hose.....	40.00

The main iron pipe, connections, shed, stop-cocks, etc., making up the balance of the initial cost.

CELERY AFTER STRAWBERRIES.

As soon as the first crop of strawberries is gathered, the vines are plowed under. That is, one summer is spent in preparing for the crop which is gathered the following spring. The patch is plowed

in season to allow for the growing of another crop of some kind during the summer and fall. During the first years of the enterprise, this second crop was celery. Celery was grown very successfully by irrigation, but it was difficult to keep for the winter market.

When setting the plants in a dry time, shallow furrows were wetted before planting. After setting out, irrigation is accomplished by turning a furrow away from each side of the row and running water down these furrows. When the water has soaked in, the furrow is turned back.

LETTUCE AFTER STRAWBERRIES.

Mr. Repp's first attempt to irrigate lettuce was made in the extremely-dry summer of 1895. The experiment was not a financial success on account of many hindrances at the start. The seed was sown about August 1st, in drills. The seed proved to be poor, and the field was replanted about the 15th. Irrigation was effected by sprinkling with hose, very much in the same way that lawns are wet. The whole field of $1\frac{3}{4}$ acres was thoroughly wetted by four men in half a day. This wetting was repeated twice a week, until the lettuce was well started. There was no rain for three or four weeks after the seed was sown, but the waterings were sufficient to produce a good crop, though reduced in value by cold weather before it was ready for market.

It will be readily seen that the amount of water used on the lettuce was very small as compared with that used in watering strawberries. Full-grown strawberry vines will give off a great deal of water through the leaves on a hot day. That water that is given off (transpired) would be especially large from a field of strawberries grown as Mr. Repp grows them, where nearly half the field is thickly covered with thrifty vines.

During the ripening and picking season of strawberries, it will be remembered that on the field in question 200 tons of water are spread over an acre in a week (when no rain falls).

The amount of water used per acre on lettuce can be calculated approximately from the capacity of the steam pump. This will pump about 40 gallons of water a minute when the water is raised 7 feet, as in this instance. One-half day equals 300 minutes— $300 \times 40 =$

12,000 gallons. This quantity was used on $1\frac{1}{2}$ acres twice a week. Twenty-four thousand gallons on $1\frac{1}{2}$ acres is 55 tons of water per acre once a week.

IRRIGATION OF ONIONS.

Mr. Repp has also irrigated onions, though his experience with this crop was less successful than with the others, as he was unable to prevent blistering; doubtless further study and experience will enable him to handle the water for this crop in a satisfactory manner.

PROFITS FROM IRRIGATION.

Mr. Repp, having irrigated since 1884, is competent to give a very correct opinion concerning the average profits of irrigation with some crops.

For some years the $5\frac{1}{2}$ acres under irrigation were devoted to growing strawberries and celery. One-half was irrigated and cropped each year. During the alternate years the land was devoted solely to the first year's growth of strawberry plants without irrigation. Immediately after the berry crop is removed, the vines are plowed under, and about the middle of August, the celery plants are set out.

Mr. Repp has irrigated strawberries, on the average, two seasons out of three since 1884. His smallest gross sales for any season in which irrigation was practiced were \$300 per acre. Average yearly gross sales of strawberries for twelve years from the $5\frac{1}{2}$ acres were \$250 per acre. It should be borne in mind that only half the area ($2\frac{1}{2}$ acres one year, 3 acres the next) bore a crop each year. The average gross sales for bearing years were \$500 per acre.

In addition to the profits from strawberries were the profits from the celery, lettuce, etc., grown on the same land.

No. 2. Josiah H. Shute, Pitman Grove, Gloucester County.

GARDEN IRRIGATION.

Mr. Shute's outfit consists of an eight-foot iron turbine windmill, set up on a thirty-foot tower; two tanks of 500 and 2,000 gallons capacity, respectively; a Buckeye double-action force pump; piping from the pump to the tanks and irrigated field, and hose for distribu-

tion of water over the field. With a storage capacity of only 2,500 gallons, Mr. Shute successfully irrigated a little over one acre during the season of 1895, selling therefrom \$250 worth of products, and having beside a plentiful supply of vegetables, etc., for family use.

The following diagram will show his arrangements:

The dotted lines represent the underground pipes. The windmill and pump supply the house and barn with water, as well as the garden. The small tank is in the attic of the house, about 20 feet above the ground. All the water is pumped into this tank, which, when nearly full, discharges through the full length of the pipe into the larger tank. The 2,000-gallon tank is on the second floor of the barn. This almost constant flow of water through the pipes under the irrigated field has kept them clean.

Pipes, furnished with faucets, come up some distance above ground at four places along the main line, to which hose is attached long enough so that any part of the field may be watered.

CROPS IRRIGATED.

Mr. Shute's specialty has been the growing of a crop of onions and celery on the same land in one season, and helping both crops by irrigation. He puts out his onion sets as early in the spring as possible, one foot by three inches. If there is dry weather while the onions are growing, he irrigates by sprinkling or by flooding. Onions should be watered early in the morning, in the evening or on a cloudy day. The onions are harvested early in July. Some are pulled early and sold in bunches with the tops on. While the onions are growing, the celery plants, "White Plume" variety, have been helped by watering, and about the middle of July are ready to transplant. These plants are set out six inches by three feet, the ground about them being thoroughly wetted. Other varieties would need to be four or five feet apart.

Mr. Shute irrigates his celery once in ten days, or two weeks. This operation is similar to Mr. Repp's method of irrigation of celery, already described. Mr. Schute has irrigated, on a smaller scale, strawberries, lima beans and other garden produce.

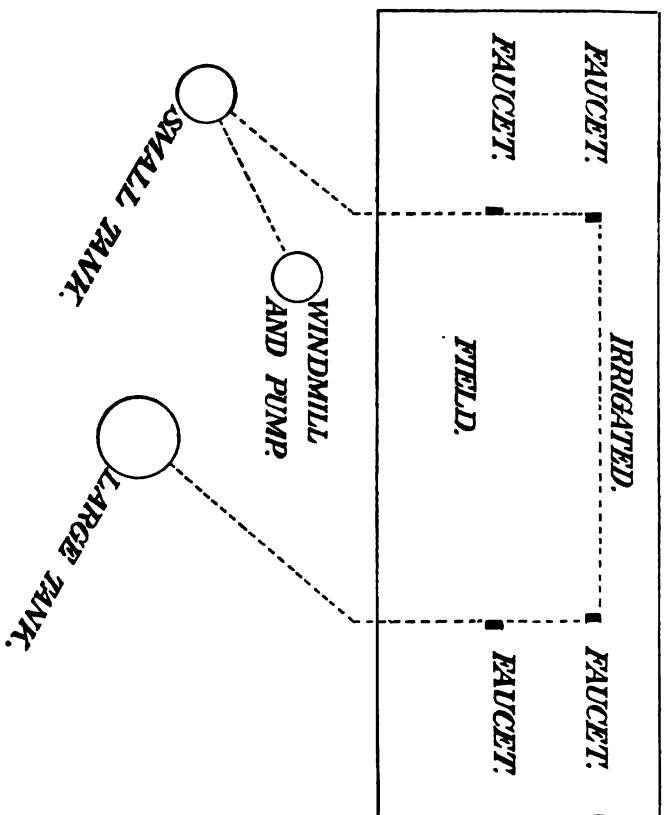


PLATE II.

COST OF PLANT.

The chief items of expense in preparing for irrigation are as follows :

Iron turbine windmill and tower, not set up.....	\$75.00
Double-action force pump.....	8.00
500-gallon tank.....	18.00
2,000-gallon tank.....	35.00
450 feet three-fourths-inch pipe, 4½ cents per foot.....	20.25
Total.....	<u>\$156.25</u>

The driven well from which the water is secured is not included in the cost of the plant, as it was put down primarily to supply the house and barn.

No. 3. A. P. Arnold, Vineland, Cumberland County.

Mr. Arnold's windmill and reservoir, located on the top of a hill, were put up for other purposes than irrigation, the latter being incidental only.

The advantages for irrigation accruing from the location of the reservoir are apparent; after the water is in the reservoir, the whole farm can be irrigated without further use of power, and in case sufficient water can be secured from the well, water rights might be sold to neighbors.

The soil on this farm is very sandy, with sandy subsoil, and, while perhaps requiring more frequent waterings, is liable to suffer more from drought than a soil of greater water-holding capacity, hence benefits from irrigation are likely to be quite as great.

The reservoir is both strong and handsome. It would probably not be necessary to expend so much money on a reservoir for irrigation purposes only. However, there is very little chance for the walls of this reservoir to crack on account of the outward pressure of the water and let the water soak out into the sandy soil.

The well was never lacking in water, although the summer and fall of 1895 were the driest known in Vineland for many years. The driven well is 70 feet deep, and it is about 35 feet to the water-level. The water for irrigation purposes can be drawn from the reservoir through a pipe connected with the lowest part of the bottom and opening some distance down the hill.

CONSTRUCTION OF RESERVOIR.

The reservoir is approximately 45 x 90 feet in area. It is very shallow at one end and gradually deepens until it is seven feet deep at the other end, where the outlet pipe is connected.

The sides are built of stone and rise about two feet above the surface of the ground. The bottom and sides are thoroughly cemented.

COST OF THE RESERVOIR, WINDMILL AND WATER WORKS.

The cost as reckoned below does not include the wages for that labor that any farmer or his help can do at odd times.

The total cost of windmill set up and water works for house and	
farm.....	\$120.00
Cost of reservoir.....	130.00

There will be some further work and expense before everything is finished. A reservoir, for irrigation purposes only, need cost much less money. Probably \$50 would buy all the material needed for a reservoir of much greater capacity, and a twelve-foot windmill set up merely for the purpose of pumping water into the reservoir would cost much less than \$120. There would be an expense, not mentioned in the above estimate, for piping to the fields to be irrigated, and a larger windmill would be required if several acres were to be irrigated.

If large, tight reservoirs are provided, wind-power may be made available for irrigation, on a fairly large scale, in southern New Jersey.

During summer droughts there is apt to be very little wind, so that at the critical time, when large quantities of water are needed, there is very little available where wind-power is the sole dependence, unless it has been pumped into reservoirs which are high enough above the land to be irrigated to permit the water to be distributed by gravity upon the land where it is needed.

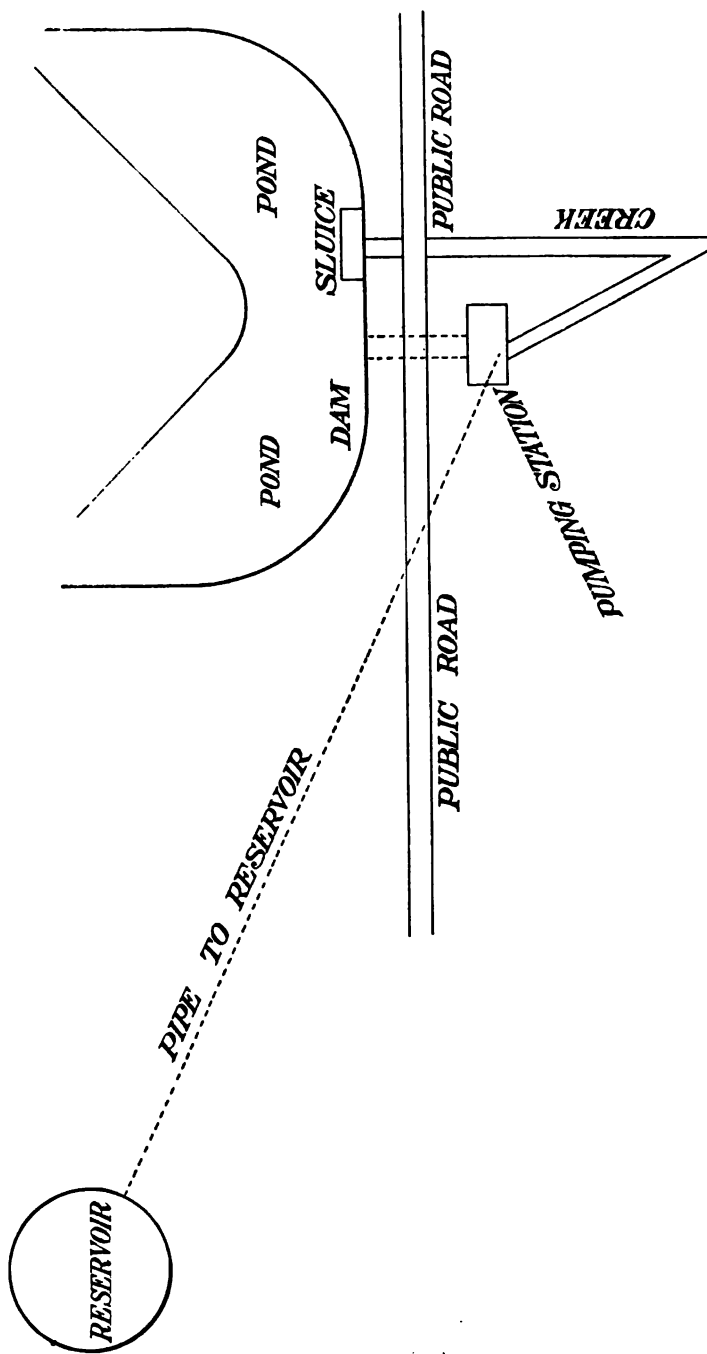


PLATE III.

No. 4. T. H. Whitney, Glassboro, Gloucester County, H. D. Chew,
Manager.

. PUMPING WATER FOR IRRIGATION BY WATER-POWER.

In the year 1894, Mr. Whitney erected a plant to irrigate, by water-power, several acres of land on one of his many farms about Glassboro.

Although the plant has not yet been used, because of a change in ownership, the arrangements are practical, and provide for irrigation at a small expense, both initial and operating. The construction and cost of the plant are the chief points considered. The accompanying sketch shows the locations, respectively, of the reservoir, dam, water-wheel, pipes, etc.

The pond on Mr. Whitney's farm covers about three and one-half acres, and is supplied by two creeks, or, rather, several springs, since the pond extends nearly to the source of both creeks. These springs furnish a very steady supply of water. A large volume of water was flowing over the dam in December, 1895, while springs and creeks were drying up all over southern New Jersey on account of the prevailing drought. The dam is about ten rods long. The water falls nine feet at the sluice, and this fall is secured by backing the water only 300 or 400 yards up the stream.

The water passes through a large conduit from the pond under the road to the top of the eight-foot overshot water-wheel. This water-wheel is connected by cogged wheels to a Worthington double-action pump. The waste-water then passes through a ditch to the main creek channel. The water for the reservoir is pumped through an underground clay pipe, two inches in diameter. The reservoir is a bowl-shaped excavation, the bottom and sides being thickly cemented. The dimensions are, approximately, 9 feet in length; bottom circumference, 55 feet; top circumference, 125 feet. It has a capacity of over 50,000 gallons, and is located on a hill 40 feet above the level of the water in the pond.

This system is evidently less expensive than one in which steam-power is used. The first cost need not be so great if the farmer uses his odd time to build the dam, lay pipes, etc. And the running expenses consist mainly in the wages of the men who apply the water to the land, no engineer being required.

The number of farms where water-power can be used in southern

New Jersey is, however, small, since the average fall in creeks is but 8 or 10 feet per mile; in the northern sections of the State this method could be used in many places. The farmer owning 10 to 20 acres could not use water-power in many cases. On large farms, or in localities where several small owners could and would co-operate, it would appear that water-power could be used to advantage to pump for irrigation purposes.

SUB-IRRIGATION.

Sub-irrigation is also practiced on Mr. Whitney's farms at Glassboro, and his method is quite unique, though there is probably very little land that can be irrigated in this way in the State.

A certain area of comparatively low land, underlaid with drain-tile, became very dry during long droughts; to remedy this, a dam was built immediately below the point where the drain outlets into the creek, and the process of drainage was reversed. That is, the water of the creek was forced back into the drain-tile, and out through the interstices into the soil, so that the latter was rendered moist within a few inches of the surface.

Mr. H. D. Chew, manager of Mr. Whitney's farms, has successfully irrigated onions and strawberries by this method.

No. 5. Mr. Theo. R. Hunt, Lambertville, Hunterdon County.

Mr. Hunt's place is located about one mile from the Delaware river, southeast from the town; the land is what is known in that section as "mountain soil;" it is a medium clay loam and with a rather compact clayey subsoil. It retains moisture only reasonably well in dry weather; it is fairly well adapted for asparagus, celery, onions, and for the small fruits, raspberries and strawberries.

Mr. Hunt has used irrigation successfully for a number of years. Previous to 1892 he obtained his water from the water works supplying the town of Lambertville. In 1892, he put in his own plant, which consists of a Regan vapor engine and the necessary mains. The engine is placed immediately upon the bank of a pond which was built many years ago for the purpose of supplying water for general use, and is not a part of the expenses included in the cost of the irrigation plant. From the engine-house, he carries his main, a two-inch iron pipe, directly west about 350 feet, which reaches an

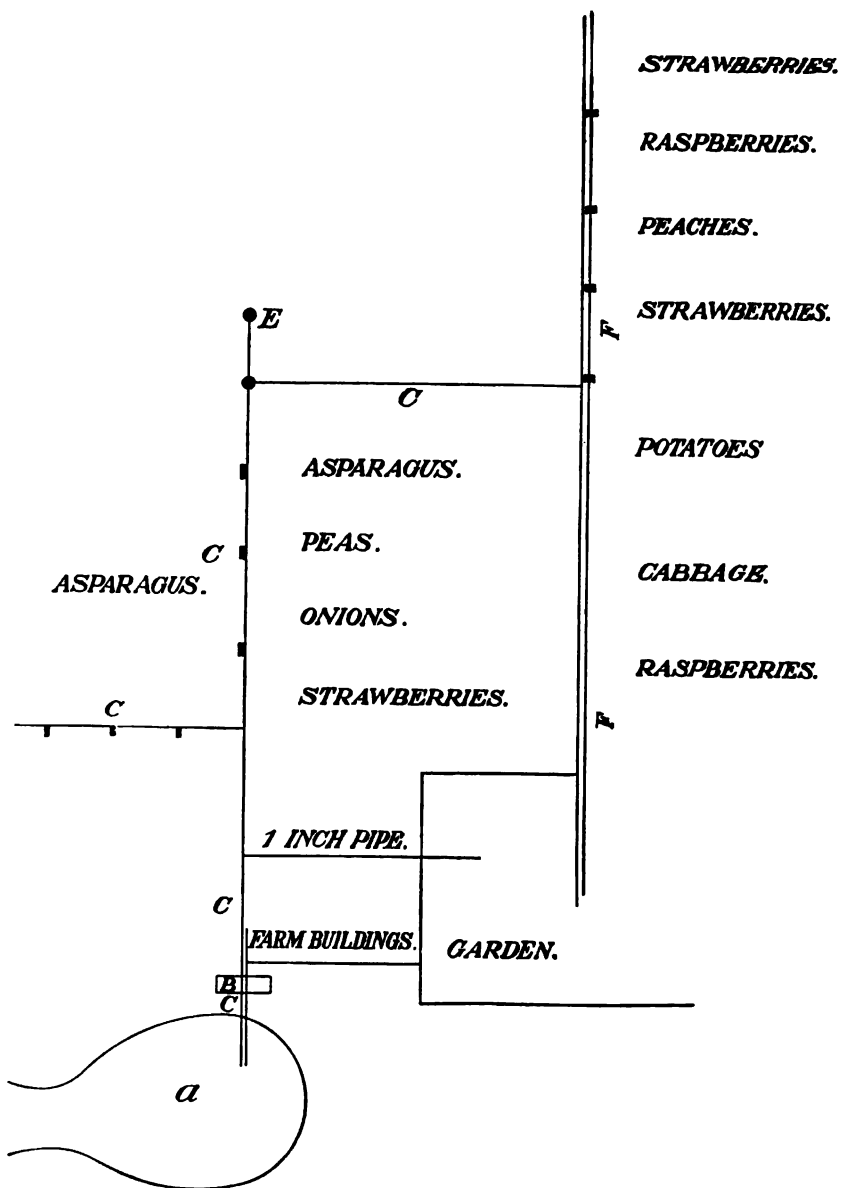


PLATE IV.

elevation about 20 feet above the level of the pond, and is high enough to permit of his carrying water by gravity to any part of the farm which he desires to irrigate; about 100 feet from the engine-house he carries a branch main of the same size about 200 feet south, in which tees are placed every 50 feet for hose connections; another one-inch pipe is carried about 150 feet north to his garden, where a large portion of his plants is grown. From the westerly point he carries a two-inch iron pipe main, arranged for connection in the same manner, about 200 feet across the public highway; from this point the water is carried by means of fire hose for several hundred feet, connected with tees every 50 feet. The area capable of being watered under present circumstances is about 10 acres. The crops which have been irrigated up to the present time are strawberries, early cabbage and celery, though the crops which he grows and which may be irrigated by his system consist of $2\frac{1}{2}$ acres of strawberries, 3 acres of raspberries, $1\frac{1}{2}$ acres of onions, 2 acres of celery, 2 acres of asparagus and three-fourths of an acre of early cabbage. The variety of crops grown permits him to distribute his water over a larger area than if the entire area was in one or two crops.

The accompanying diagram gives a very good idea of the situation of the plant, and is described somewhat in detail, since it is representative of a large number of locations in the northern sections of the State.

A represents the pond, which covers about half an acre, and is supplied by a stream large enough to meet all demands for irrigation. *B* is the engine-house; *C C C C* show the location and direction of the mains, and *D* the one-inch pipe running to the garden; *E* is the westerly point of the main at which a tee is placed; it has an elevation of about 20 feet above the level of the pond; *F F* show the fire hose, which may be carried several hundred feet both west and east of the main, and *G* shows the highway. The areas showing asparagus and onions, south of the main pipe, slope toward the pond; the asparagus may be irrigated by attaching the fire hose at *E*. The areas showing asparagus, peas, onions and strawberries slope both toward the pond and the highway, and may therefore be irrigated in two directions. The area north of the highway is quite irregular, though sloping quite rapidly toward the north, and is capable of irrigation mainly in the one direction, north. The garden is nearly on a level with the pond.

THE COST OF IRRIGATION.

The main items of cost are gas engine, \$260; iron pipe for main, \$100; the cost of the main is somewhat low, because it consists of old boiler pipe, which was secured very cheaply. The cost of the old fire hose is merely nominal, and in the experience of Mr. Hunt is an excellent substitute for iron, where no pressure is expected. For distributing, he uses hose made from twelve-ounce ducking, costing 12 cents per yard; this cut into strips, three to the yard, and sewed together, and then dipped into hot coal tar, he finds very cheap and serviceable.

The expense of running the engine is entirely measured by the cost of the gasoline, which ranges from 3 to 5 cents per hour, depending upon whether gasoline is purchased at retail or at wholesale. The engine requires no attention after starting. The application of the water requires the attention of one man, in order to prevent waste; it is applied entirely in rows, except upon young plants, as cabbage and celery, when it is sprinkled.

The distribution is effected by means of a trough or gutter, the sides of which are perforated at different distances, enabling him to adjust it to the width of the rows of the various crops grown. In irrigating strawberries, however, the water is simply allowed to run between the rows under the mulch. The capacity of the engine is 1,500 gallons per hour, which enables him to irrigate thoroughly at least one-half acre per day. Irrigation is never practiced until the ground becomes dry, and in the case of cultivated plants, as celery, cabbage, etc., the land is cultivated as soon after as it is dry enough, to prevent baking.

Mr. Hunt regrets now that he did not put in an engine with a capacity of 4,000 gallons an hour, a quantity that could be carried by his main, and which at the present time would cost but little more than the one he now has.

THE ADVANTAGES DERIVED.

The first year in which the plant was in operation—1892—the irrigation of one acre of celery more than paid for the entire cost of the plant, and Mr. Hunt estimates that the value of the water merely for the purpose of wetting his plants, both before and at the time of

setting, more than pays annually the initial cost of the plant, and, though he has kept no accurate record of the profits secured from irrigation, the good results are so apparent that anyone visiting his place is deeply impressed with the value of the system. His berries, particularly, are of very fine quality—in fact, so superior that he is able to fix his own prices in his chief markets, Lambertville and Scranton.

POSSIBILITY OF PUMPING LARGE QUANTITIES OF WATER FROM WELLS FOR IRRIGATION PURPOSES.

In the two cases cited, where water was pumped from wells to be used for irrigation, only a small acreage was irrigated. In order to discover if it were possible to pump large quantities of water from wells, the water works of Vineland, Cumberland county, were investigated.

The water for the Vineland water works is pumped from 14 driven wells, 2½ inches in diameter, to a high reservoir. The distance from surface of water in the wells to the top of the tank used as a reservoir is 95 feet. The water is raised to this height by steam-pumps. The average amount of water pumped daily is 250,000 gallons. It was impossible to secure data, even approximately, concerning the cost of pumping this water.

The experience of the Vineland Water Works Company proves that it is possible to pump enough water at one place, at least, in southern New Jersey, to irrigate a large tract of land.

It is not probable that such prolific wells as were found by the Vineland Water Works Company exist in many places. But, on the other hand, not many farmers would want to irrigate more than five acres. It is quite probable that the most economical method of irrigation will prove to be for several farmers to co-operate in building a central pumping station, the water to be conveyed from this station to large reservoirs on the farms of the co-operating members.

IRRIGATION EXPERIMENTS IN NEW JERSEY.

In 1895, arrangements were made that rendered it possible to secure at the College Farm—now under the control of the Experiment Stations—an abundance of water for irrigation purposes, and plans were made

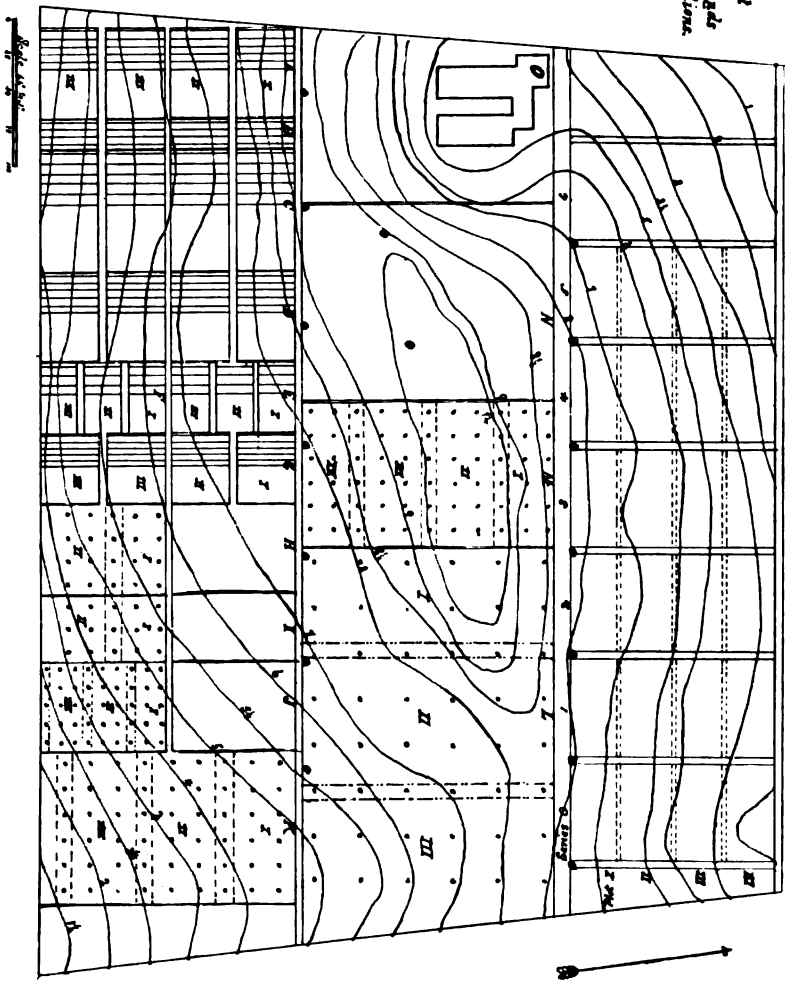
at once to study the question of irrigation in a broad way, both in reference to the kind and variety of crops and the methods of applying water. The cost of irrigation is not included in the study, further than to record the expenses attending the application of the water, as the conditions under which the water was obtained could not be duplicated throughout the State.

The crops that are growing now and which shall be grown later, include a large number of vegetables which, as a rule, require an abundance of water in order to secure earliness and high quality, and which are especially adapted to the conditions existing in the State. Chief among these are asparagus, celery, cucumbers, cabbages, beets, beans, peas, peppers, potatoes, tomatoes and turnips, including both early and late crops where the kind of vegetable permits. Among the fruits are included strawberries, blackberries, raspberries, gooseberries, currants, plums, cherries and pears.

The methods to be investigated include both surface and sub-irrigation. The furrow and flooding system for surface irrigation will be given careful trial, while in sub-irrigation both the usefulness of the various kinds of tile and the influence of depth of placing them will be studied. The plants selected include, as a rule, the standard sorts and varieties, and wherever practicable each irrigated area will include from two to four plots, each treated in a different manner, particularly in respect to fertilizing and manuring. The accompanying map, with description of the plant, indicates the plan and scope of the work outlined.

The experiment ground contains seven acres, separated by lanes 9 feet wide, into three divisions, the higher ground in the middle division. The contour lines show a fall of $9\frac{1}{2}$ feet from the highest to the lowest points, and that upon a large portion of the area there is a reasonable uniformity in the slope of the land, thus permitting a ready and sufficiently rapid flow of water. The water is supplied by a three-inch main, which runs through the middle division; tees are placed every 75 feet, from which laterals, 1 inch inside diameter, are carried both north and south, ending in hydrants raised 3 feet from the ground, and provided with faucets to which hose may be attached for distributing the water. The fall from the reservoir is about 9 feet, thus affording a reasonably rapid flow from the laterals, and the supply is ample for the maximum demands for irrigation purposes. The division lying on the north contains about two acres, and is separated into

Experiment
Grounds
N.J. Station



four plots, numbered in the map I., II., III., IV., which are divided again, north and south, into seven series of plots, indicated by the numerals, 0, 1, 2, 3, 4, 5, and 6; a portion of each series, approximately one-sixth, is arranged for irrigation; the water runs north from the stand-pipes, and may be applied first to plot IV., then III., etc., or to I., II. and III., etc., as the line of experimentation may indicate.

With the exception of asparagus, the different kinds of vegetables mentioned as under experiment are grown on these plots, and various methods of surface and sub-irrigation used are practiced.

The area lying on the south side contains $3\frac{1}{2}$ acres, and is divided into 10 plots, running north and south, marked A, B, C, etc., the area of each plot being determined by the kind of crop and object of the experiment; the plots are also subdivided into plats or belts, numbered I., II., III., etc., running east and west. With the exception of plots B and K, one-half of each plot is arranged for irrigation.

For example, plot A contains six varieties of asparagus, represented by the lines running north and south; these varieties are duplicated on the blank space, which represents the irrigated area of the plot. Plot C contains six varieties of blackberries; plot D, six of raspberries; plot E, four of currants; plot F, four of gooseberries, and plot G, six of strawberries. These plots are also subdivided into plats or belts, I., II., III., etc., for the purpose of studying methods of culture and fertilization. In plots H, containing plums; I, cherries, and J, pears, the upper portion is irrigated and each belt of two rows of trees each in the plots is separated from the other by a single row of trees, containing different varieties of the same kind of fruit, for a variety test; the purpose of this separation being to prevent cross-feeding.

Plots K, in which standard pears are set, L, containing apples, and M, peaches, are situated in the middle division on the higher portion of the land, and are not duplicated for irrigation, though it may be practiced in case necessity demands. Plot N is arranged more particularly to study methods of irrigation; it contains a number of methods of applying the water, both by surface and sub-irrigation methods. O shows the plant-houses, where sub-irrigation is a feature of the work planned for the winter season.

It will be observed from this description of the plant that opportunity is afforded for a broad study of the question of irrigation as applied to the crops of the greatest importance in our State. A small

part only of this plant was in operation in 1895. It was finished too late to permit of a proper study of the effect of irrigation, except in case of a few late vegetables. Irrigation began on September 17th, and continued until the end of the season, upon beans, peppers, egg-plants, tomatoes, turnips and celery. For egg-plants and tomatoes, irrigation began too late to be of service; the turnip crop was ruined by club-root, thus leaving but three crops from which positive data could be secured. The complete data obtained are contained in Bulletin No. 115 of the Station.

REPORT OF THE BIOLOGIST.

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REPORT OF THE BIOLOGIST.

JULIUS NELSON, PH.D.

I.

OUTLINE OF THE WORK OF THE YEAR.

Investigations in the Biological Department have been conducted along three distinct lines, as follows:

(1) Observations recording the normal fluctuation of the temperature of cows. The object being to obtain data that will enable us to make a closer calculation of the extent of reaction given by tuberculous cows when tested with tuberculin.

The data found in Tables 1 and 2 of this report complete the series begun in 1894.

(2) Experiments upon a quarantined herd of tuberculous animals have been continued. A number of questions are involved in this direction. "What is the effect of repeated injections of tuberculin; is it curative or the reverse?" Our results show, in harmony with those of Professor Bang and others, that no direct statement can be made on the subject. It depends on the cow, the condition of its disease, and other as yet unknown factors. Recorded temperatures of injections on animals, both of those tested for the first time and of others tested a dozen times, are found in Tables 3 to 6, inclusive. It seems as if tuberculin may have a beneficial effect upon healthy or non-tuberculous cows. This subject has, however, not been pursued very far as yet.

(3) Studies have been taken up of the germ content of milk, beginning first with the milk as found in the udder. Our Tables 7 and 8 are well worth looking at as showing to what extent milk may be on its way to souring even before it is drawn. The subject is full of promise and practical results and has been studied only in a

preliminary way as yet. So we do not in this report discuss the matter at length.

We have also prepared a bulletin for the general public and the farmer, giving a great deal of information about consumption, and showing the way to its suppression, both among animals and human beings.

II.

EXPERIMENTAL WORK.

a. A DISCUSSION OF RESULTS SHOWN IN THE TABLES.

The first two tables herewith published present the concluding data on the normal temperature of cows. Reports of the Biologist for 1894 and 1895 contain the previous issues of this series. A superficial study of them has already been made, and a preliminary report given, which has been published, in connection with other results, in the Proceedings of the American Association for the Advancement of Science—last Springfield meeting (1895). But we withhold any discussion of them at this time and place until the extensive data can be more thoroughly studied.

Tables 3 to 5 show the effect of repeated injection of the experimental herd, which consists of animals that have reacted to the tuberculin test or else have given a temperature record which is suspicious. Cow No. 26, however, has never reacted to tuberculin.

The present injections are a continuation of the series of injections reported by the Biologist in 1895. It was then shown that reacting cattle do not give so strong a reaction when injected subsequently as they do on the first application of the tuberculin test, and that this insensibility to tuberculin increases with each injection. Some observers have reported that the sensibility in such cases could be restored by a prolonged period of rest. The last time this herd had been injected was October 5th, 1895. The date of resuming the testing is May 16th, 1896. From the table we see that 59, 95 and possibly 14 show moderate or small reactions. No. 59 reacted on the sixth injection, failed to do so on the seventh and now is sensitive again on the eighth injection. No. 95 has a somewhat similar record. No. 14 had been injected nine times previously. It last reacted on

the seventh injection. It may, therefore, be concluded that the general statement that rest from injection tends to restore the sensibility is true. But our tables also show that cows differ so much that what is observed with one case is not applicable to all. Prof. Bang, who has an experimental herd similar to ours but very many times larger, has experimented considerably in this direction, and has found great variation among cows as regards their behavior to re-injection. Some animals fail to react on the second injection and respond on the third. Others keep on reacting under a number of re-injections. The subject is one of great scientific interest and requires much further study.

This has a practical bearing on the question of weeding out tuberculous animals, when their reacting temperatures are so low as to leave interpretation in doubt. It also has a bearing on the testing of cattle to be admitted into herds which the owners desire to be kept free from contamination.

It is evidently necessary to be cautious, lest a cow be purchased, which has given a reaction to tuberculin, but is declared by the seller not to have been tested.

The question is also involved in that of the curative effect of tuberculin repeatedly injected. Some would believe that the lack of reaction or lowered reaction is evidence of a curative process going on as a result of the injection. As we know that badly-tuberculous cows frequently show no response to tuberculin injection, it is plain that we have no ground for such belief. In fact we are deeper bemuddled than ever when we try to explain the rather wonderful fact that a tuberculous cow reacts to injection generally but not always. Why the exception? Also that there remain a very few cases that show reaction when no tuberculosis can be found. This has never been explained.

The curative effect of tuberculin is one exercised in a very desultory fashion. In some cases it has been known to effect what appears to be a cure. In others it has evidently greatly retarded the development of tubercular disease, and yet in others it hastens that development. Our case 58 is to the point. She began to show evident signs of failing health, and after testing her for the ninth time, as shown in Table 5, she was slaughtered, and the autopsy revealed the following state of things: Udder and its lymphatics, normal; liver, normal. All mediastinal glands much enlarged and caseated. Lungs, with the posterior half of right cephalic lobe solid, enlarged, caseated and adherent to diaphragm. Middle lobe with two tubercles the size-

of plums. Posterior lobe with a lump as large as an apple. Each of the left lobes contained nodules about as large as plums. Only a few nodules seen on the intestines, but both kidneys were extensively invaded by tubercular growth that affected not only their capsules and adjacent fat masses, but penetrated throughout the kidney from the cortex even to the pelvis. The right kidney was affected on its anterior third, with miliary tuberculosis on its surface and the parenchyma was full of small tubercles; evidently the kidney had been infected from the circulation. But if the circulation was so thoroughly laden with germs the wonder is that so few organs should have become involved. The left kidney was tuberculous at its middle portion the entire cortex, dorsal, ventral and external, was hypertrophied with tuberculous growths that deeply involved the parenchyma. Possibly at its earlier injection this reacting animal had suffered the dissipation of a tubercle that infected the circulation and thus both kidneys. Possibly these organs were endeavoring to excrete the germs. This suggests that soon after reaction, tuberculous animals may be passing germs through their urine. It is strange that the udder should have remained free from infection. At the time of injection this animal was suffering from well-developed fever, which subsided when the tuberculin began to act. I have frequently noticed this phenomenon in tuberculous cows that had high temperature when injected.

In 58's case tuberculin certainly did no good and probably greatly hastened her death. Prof. Bang reports that he has repeatedly injected his herd of tuberculous animals and found no evidence that the disease was hastened.

Our No. 26, which has never reacted and which has received injections twelve times, appears none the worse. It is kept with the tuberculous cows to see if it will get tuberculosis. It may be that repeated injection of tuberculin into healthy cows will render them immune.

b. GERMS IN MILK.

The question of the purity and wholesomeness of our milk is not restricted to the consideration of tubercle germs, which are rarely present in animals that appear physically healthy, even though they react to tuberculin and show tuberculous lesions on autopsy. This subject we have discussed at length in Part III of this report. But

milk not only may have but always does have a host of other germs of many kinds, which, though not usually of the pathological sort, still deprive milk of its purest flavor, and soon spoil it, as they rapidly develop while the milk is awaiting its use in the dietary of invalids and others. These germs come into the milk from the air, the hair on the udder and belly of the cow, the hands and sleeves of the milker, the dirt that adheres to the teats and the manure the cow swishes about with her tail so vigorously in fly-time. Even the flies get drowned in the milk before it is strained and get their six germ-laden feet well washed off—feet and also tongue that have adhered to all kinds of filth.

Germs get into the milk through the lack of careful cleansing and sterilization of the vessels in which it is handled and stored. They blow in with the dust; they are in the water used to wash the pails and pans, and this water comes from—who knows what its course has been on the surface and beneath the surface of the earth?

But our investigations have not been made with reference to these germs. Our question is, is the milk pure in the udder? Late investigations have shown how erroneous are the older notions that milk in the udder is sterile, and the presence of germs found in the milk as drawn has been explained as an infection from outside, the germs entering the ends of the teats and working up. This matter requires further study. It seems likely that after milking is finished a few germs may remain in the milk ducts and during the next twelve hours will have multiplied sufficiently to account for the many that are then found. We have begun investigations of this question and our preliminary results are shown in Tables 7 and 8. It will be seen that cows vary much in respect to the extent of this infection, our No. 26 having its milk much more charged with germs than is the milk of its tuberculous neighbors. It is interesting to note that the milk that is in the teats and lower part of the udder is the most contaminated, as the germs decrease with each additional spurt of milk drawn.

Table 8 is more reliable than Table 7 in its details, as the culture medium used was fresher. It is well known that all the germs in water do not develop when introduced into gelatin, and this may be also true of milk germs. Into questions of technique and other matters connected with this inquiry we shall not enter at this time; when the researches are further advanced the subject will be fully and specially treated.

TABLE 1.

Cow Temperatures, 1896.

(Temperatures above 100 degrees are indicated only by units and tenths)

DATE AND HOUR.	Tag 3	Tag 59	Tag 72	Tag 95	Tag 26	Tag 14	Tag 58	Tag 88	Tag 87	Woodlawn.	Blanket.	Blindy.	Tag 62	Tag 25	Temperature of Air—Degrees Fahrenheit.
Jan. 24, 6:00 P. M.....	1.3	2.1	0.3	1.3	0.6	99.0	3.0	0.9	0.7	1.6	1.2	0.8	0.7	1.6	.....
" " 7:00 "	0.6	2.6	0.8	1.6	0.2	99.5	3.5	1.1	0.4	1.3	1.4	0.8	0.7	1.3	48
" " 7:30 "	0.2	2.6	0.7	1.2	0.3	99.8	3.7	1.6	0.6	0.7	1.2	0.4	0.7	0.9	.....
" " 8:00 "	0.6	2.6	1.0	1.3	0.3	0.2	4.0	0.8	0.6	0.6	1.2	0.4	0.6	0.5	.....
" " 8:30 "	0.2	2.5	1.2	1.4	0.5	0.4	3.8	0.8	0.4	0.4	0.3	1.0	1.2	0.6	.....
" " 9:00 "	0.7	2.5	1.2	1.3	0.3	0.2	3.8	1.0	0.2	0.2	0.2	1.2	1.3	0.5	.....
" " 9:30 "	0.3	2.5	0.5	1.0	0.1	0.5	3.8	1.0	0.5	0.5	1.0	1.2	1.4	0.7	.....
" " 10:00 "	0.5	2.5	1.2	0.8	0.1	0.6	3.9	0.5	0.4	0.7	1.0	1.3	1.3	0.6	51
" 25, 12:00 Midnight.....	1.0	2.5	0.3	1.1	0.0	0.5	4.0	0.4	1.0	0.8	0.5	0.5	1.0	0.7	50.5
" " 2:00 A. M.....	0.8	2.0	0.0	1.1	0.3	0.4	3.6	0.5	0.4	0.6	0.0	0.4	1.2	1.3	.....
" " 4:00 "	0.4	2.5	0.5	1.1	0.0	0.6	3.5	0.5	1.0	0.7	0.5	0.4	0.5	0.8	48
" " 5:00 "	0.0	2.5	0.3	1.2	0.1	0.7	3.0	0.3	0.5	0.5	0.2	0.4	0.8	1.1	.....
" " 6:00 "	0.4	2.4	0.5	1.7	0.5	1.0	2.5	0.5	0.5	0.7	0.4	0.6	1.2	1.0	45
*Fed 6:30 "	0.5	2.5	0.7	2.4	1.3	1.6	2.8	0.4	0.6	0.6	0.1	1.0	0.7	1.1	.....
Jan. 25, 7:00 "	0.6	2.8	1.0	2.7	1.0	2.1	2.6	0.4	0.4	0.6	0.0	0.5	0.8	0.7	42
" " 8:00 "	0.2	3.0	1.4	2.1	1.3	1.7	2.2	0.7	0.5	0.6	0.4	0.1	0.8	1.3	.....
" " 8:30 "	0.0	2.9	1.0	2.1	1.5	1.6	2.2	0.3	0.2	1.6	1.0	0.3	1.2	1.5	.....
" " 9:00 "	0.0	2.8	0.6	2.2	1.5	2.0	2.3	0.8	0.6	1.5	0.8	0.6	1.2	1.5	44
" " 9:30 "	0.4	2.5	0.8	2.1	2.0	2.1	2.2	0.4	0.2	1.4	1.2	1.2	1.2	1.4	.....
" " 10:00 "	0.2	2.6	1.0	2.1	2.0	2.3	2.0	0.0	0.2	1.4	1.0	1.2	0.8	1.3	.....
Water 10:30 "	0.0	2.2	0.4	0.0	1.1	0.6	0.8	0.4	0.4	1.2	0.6	0.9	1.0	1.1	.....
Jan. 25, 11:00 "	98.0	1.0	0.0	98.4	99.5	99.7	99.8	0.6	0.7	0.6	0.5	1.3	1.3	1.2	47
" " 11:30 "	98.0	1.4	99.2	98.0	0.0	99.7	99.9	0.3	0.2	1.2	0.6	0.9	1.5	0.9	.....
Fed 12:00 Noon.....	98.6	1.6	0.1	98.5	0.2	0.2	0.2	0.2	0.5	1.2	0.6	1.1	1.5	1.1	43
Jan. 25, 1:00 P. M.....	99.4	2.6	0.6	99.6	1.7	1.5	1.4	0.4	0.4	1.3	1.0	1.1	1.4	0.9	.....
" " 1:30 "	99.8	2.6	1.0	99.8	1.8	1.2	1.8	0.4	0.6	1.3	0.7	0.8	1.3	0.4	.....
" " 2:00 "	0.4	2.3	1.0	0.4	1.6	1.4	2.0	0.4	0.4	0.6	0.0	0.5	0.9	0.2	47.5
" " 2:30 "	0.4	2.6	0.6	0.5	1.5	1.3	1.7	0.5	0.4	0.6	0.2	1.2	1.4	0.6	.....
" " 3:00 "	0.7	2.5	0.4	0.2	1.6	1.1	2.1	0.7	0.4	1.2	0.4	1.4	1.5	0.5	.....
" " 3:30 "	99.9	2.2	0.6	0.7	1.2	1.2	2.1	0.3	0.2	0.8	0.4	1.2	1.3	0.8	.....

*See note at end of Table 1.

TABLE 1.—Continued.

Cow Temperatures, 1896.

(Temperatures above 100 degrees are indicated only by units and tenths.)

DATE AND HOUR.	Tag 3	Tag 59	Tag 72	Tag 95	Tag 26	Tag 14	Tag 58	Tag 88	Tag 87	Woodlawn.	Blanket.	Blindy.	Tag 62	Tag 25	Temperature of Air—Degrees Fahrenheit.
Jan. 25, 4:00 P. M.....	99.5	2.5	0.6	0.5	1.2	1.0	2.4	0.4	0.4	1.1	0.6	0.8	0.8	0.6	47.5
Water 5:00 "	99.6	2.5	99.7	0.7	0.1	0.6	99.3	0.2	0.5	0.8	0.5	0.8	1.0	0.8	.....
Fed 6:00 "	99.4	2.3	0.3	0.7	0.3	0.6	99.1	0.3	0.4	1.2	0.4	0.7	1.5	1.5	47
Jan. 25, 7:00 "	0.3	2.5	1.2	1.0	0.6	0.6	0.5	1.0	1.1	0.0	0.7	1.4	1.7	1.2	.....
" " 7:30 "	0.5	2.2	0.4	1.0	0.6	0.4	0.5	1.1	1.2	1.1	1.0	0.7	1.7	1.3	.....
" " 8:00 "	0.3	2.2	0.6	0.9	0.7	0.5	0.3	0.7	1.3	0.8	0.6	1.0	1.5	0.8	49
" " 8:30 "	0.4	2.4	0.3	0.9	0.5	0.6	0.5	0.5	0.9	1.3	0.7	1.3	0.9	0.8	.....
" " 9:00 "	0.2	1.9	0.7	0.9	0.0	0.9	1.2	0.3	0.6	0.4	0.9	1.1	1.0	0.9	49.5
" " 9:30 "	0.6	1.7	0.1	0.7	99.8	0.9	1.3	0.9	0.9	1.2	0.9	0.8	1.4	0.9	.....
" " 10:00 "	0.9	2.4	0.4	0.9	0.6	0.8	1.7	1.1	1.0	1.2	0.5	0.9	1.5	1.1	50
" " 12:00 Midnight.....	0.7	1.6	0.1	0.8	0.1	0.7	1.3	0.8	0.8	1.0	0.7	0.8	0.6	1.6	.....
" 26, 2:00 A. M.....	0.9	2.1	0.3	0.7	0.0	0.7	1.7	0.3	1.0	1.1	0.3	0.8	1.4	1.1	.....
" " 4:00 "	0.3	1.7	0.2	1.2	0.7	0.8	1.7	1.4	1.3	0.5	0.2	0.2	0.8	1.1	49
" " 5:00 "	0.3	1.5	0.5	1.0	0.5	0.9	1.7	0.6	1.3	1.1	0.7	0.6	1.4	1.3	47
" " 6:00 "	99.5	1.8	0.6	1.4	0.6	0.6	1.3	0.6	0.5	1.2	0.7	0.5	0.9	0.8	.....
" " 6:30 "	0.5	2.0	0.5	1.6	0.6	0.8	1.7	0.9	0.6	1.0	0.6	0.8	1.2	1.0	.....
Fed 7:00 "	0.4	2.0	0.6	1.4	0.6	0.7	1.6	0.5	0.9	1.2	0.8	1.3	1.2	1.4	.....
Jan. 26, 8:00 "	0.6	2.7	1.2	2.6	1.3	1.8	2.3	0.3	1.2	1.4	1.2	0.4	1.5	1.4	.....
" " 8:30 "	0.4	2.6	1.4	2.5	0.7	1.6	1.9	0.4	0.8	1.4	1.0	0.8	1.0	0.8	.....
" " 9:00 "	1.2	2.8	1.3	2.5	1.6	1.4	1.7	0.3	0.5	1.3	1.5	1.2	1.5	1.0	.....
" " 9:30 "	1.2	2.9	1.5	2.5	1.4	1.9	2.1	99.8	99.4	1.2	1.8	0.7	1.7	0.9	.....
" " 10:00 "	1.1	2.5	0.7	2.1	1.1	1.6	2.0	99.5	99.6	0.6	1.2	0.4	1.4	1.2	.....
Water 10:30 "	99.3	0.6	0.1	99.4	0.2	0.3	1.3	0.2	99.4	1.2	1.0	1.2	1.5	0.8	.....
Jan. 26, 11:00 "	99.1	0.5	99.4	99.1	0.3	0.2	1.1	99.7	99.4	1.2	0.4	1.0	1.2	0.7	48.5
" " 11:30 "	99.0	0.7	0.5	99.1	0.2	99.8	1.4	0.4	0.0	1.4	99.6	0.8	1.4	1.2	.....
Fed 12:00 Noon.....	99.6	1.1	0.0	99.7	0.6	0.5	1.6	0.7	0.2	0.6	0.0	0.9	1.5	1.3	49
Jan. 26, 12:30 P. M.....	99.5	1.3	0.2	0.0	0.9	0.5	1.6	0.3	0.2	0.6	0.1	0.8	1.5	0.8	.....
" " 1:30 "	0.9	2.1	0.4	0.8	0.1	1.3	2.3	0.2	0.7	1.3	0.2	0.5	1.6	0.6	.....
" " 2:00 "	0.9	2.0	0.5	0.7	0.4	1.2	1.9	99.8	0.3	1.2	0.1	0.6	1.2	0.6	.....
" " 2:30 "	0.4	1.6	0.4	0.6	0.5	1.1	2.2	0.6	0.8	1.4	0.5	0.4	1.6	0.8	.....
" " 3:00 "	0.3	1.6	0.9	0.4	0.4	1.1	2.6	0.3	0.4	1.2	0.3	0.6	1.6	0.8	.....

TABLE 1.—Continued.

Cow Temperatures, 1896.

(Temperatures above 100 degrees are indicated only by units and tenths.)

DATE AND HOUR.	Tag 3	Tag 59	Tag 72	Tag 95	Tag 26	Tag 14	Tag 58	Tag 88	Tag 87	Woodlawn.	Blanket.	Blindy.	Tag 62	Tag 25	Temperature of Air—Degrees Fahrenheit.
Jan. 26, 3:30 P. M.....	1.0	2.1	0.4	0.9	0.6	1.2	2.6	0.0	0.4	1.3	0.3	0.9	1.9	0.8	47
“ “ 4:00 “	0.7	2.3	0.1	0.8	0.3	1.3	2.6	0.4	0.5	1.2	0.6	0.5	1.4	0.8	.....
Water 5:00 “	99.5	2.2	99.2	1.2	99.2	0.2	1.3	0.4	0.1	1.0	0.6	0.4	1.1	1.3	44.5
Fed 6:00 “	99.6	2.2	99.7	0.8	0.2	1.3	1.4	0.3	0.1	0.4	0.4	0.5	0.6	1.3	.....
Jan. 26, 7:00 “	1.5	2.4	0.5	1.2	0.4	1.4	1.8	1.0	0.3	1.0	1.3	1.2	0.6	0.6	.....
“ “ 7:30 “	2.0	2.4	0.4	1.3	0.3	1.4	2.0	1.1	0.5	1.0	1.2	1.4	0.5	0.8	.....
“ “ 8:00 “	2.5	2.0	0.8	1.1	0.3	1.3	2.0	0.4	0.4	0.6	0.7	0.9	0.3	1.0	44
“ “ 8:30 “	2.5	1.6	0.5	1.2	0.3	1.3	2.1	0.1	0.4	0.5	0.5	0.4	0.6	0.6	.....
“ “ 9:00 “	2.7	2.2	0.3	1.2	0.4	1.0	2.2	0.3	0.3	0.6	0.7	0.6	0.7	0.7	.....
“ “ 9:30 “	2.3	2.2	1.0	1.2	0.3	0.6	2.1	0.5	0.4	0.7	0.8	0.8	0.9	0.7	.....
“ “ 10:00 “	1.8	1.8	0.8	1.1	0.2	0.5	2.1	0.5	0.8	1.0	0.6	1.2	0.7	0.8	45
“ “ 12:00 Midnight.....	1.4	1.4	0.4	1.2	0.0	0.5	2.3	0.7	0.6	0.6	0.4	0.6	1.1	0.8	.....
“ 27, 2:00 A. M.....	1.8	1.6	0.3	1.3	0.2	0.9	2.2	0.3	0.6	0.5	0.3	0.2	0.5	1.2	.....
“ “ 4:00 “	2.5	2.4	0.4	0.9	0.2	0.6	2.2	0.6	0.2	1.2	0.0	0.4	0.5	0.7	42.5
“ “ 5:00 “	3.0	2.3	0.8	1.2	0.5	0.8	2.0	0.7	0.6	0.8	0.2	0.5	1.3	0.6	.....
“ “ 6:00 “	3.5	2.2	0.5	1.5	0.3	0.7	1.5	0.3	0.3	0.5	0.2	0.4	0.9	0.6	40
“ “ 6:30 “	3.8	2.6	1.1	1.5	0.5	1.0	1.7	0.4	0.3	0.8	0.4	0.6	0.8	0.7	.....
Fed 7:00 “	3.7	2.4	0.8	1.6	0.6	1.2	1.6	0.2	0.5	1.2	0.2	0.4	0.5	1.1	.....
Feb. 7, 6:00 P. M.....	0.3	0.7	0.6	1.1	0.7	0.6	1.0	0.7	0.6	1.1	1.2	0.6	1.8	1.5	.....
“ “ 7:00 “	0.2	0.5	0.7	1.1	0.7	0.6	1.1	0.6	0.8	0.8	1.0	1.0	1.6	1.1	44
“ “ 7:30 “	0.2	0.6	0.5	0.9	0.6	0.8	1.2	1.0	1.0	0.8	0.9	1.2	2.0	1.0	.....
“ “ 8:00 “	0.3	1.0	0.4	0.8	1.0	0.7	1.4	1.1	1.1	1.0	0.8	1.2	2.1	0.8	.....
“ “ 9:00 “	0.3	0.6	0.6	1.0	0.8	0.7	1.1	1.0	1.1	0.7	1.1	0.8	2.1	0.4	42
“ “ 10:00 “	0.4	0.7	0.3	0.8	0.7	0.6	0.8	1.1	1.1	0.8	0.9	0.4	1.6	0.6	.....
“ “ 12:00 Midnight.....	0.4	0.5	0.1	1.0	0.2	0.5	1.0	0.6	0.8	0.8	0.6	0.2	2.0	0.9	41.5
“ 8, 2:00 A. M.....	0.4	1.0	0.1	0.6	0.4	0.5	0.9	0.7	1.0	0.8	0.6	0.3	1.8	1.1	40
“ “ 4:00 “	0.4	0.3	0.1	0.6	0.2	0.6	1.0	0.6	0.5	0.9	0.5	0.2	1.4	1.0	.....
“ “ 5:00 “	0.3	0.9	0.2	0.7	0.3	0.7	1.1	0.4	0.5	0.8	0.5	0.2	1.6	0.7	37
“ “ 6:00 “	0.7	0.5	0.7	1.2	0.4	0.6	1.2	1.1	0.7	0.6	0.5	0.5	1.7	0.7	.....
Fed 7:00 “	0.6	0.8	0.5	1.9	1.0	1.4	2.1	0.4	0.2	0.8	0.4	0.8	1.4	0.9	38
Feb. 8, 7:30 “	0.6	1.4	1.1	2.1	1.2	1.6	1.9	0.6	0.6	1.4	0.8	1.0	1.3	1.2	.....
“ “ 8:00 “	0.7	1.4	1.2	2.2	1.1	1.6	1.7	0.7	1.2	1.2	1.2	1.1	1.5	1.5	39

TABLE 1.—Continued.

Cow Temperatures, 1896.

(Temperatures above 100 degrees are indicated only by units and tenths.)

DATE AND HOUR.	Tag	Tag	Tag	Tag	Tag	Tag	Tag	Tag	Tag	Woodlawn.	Blanket.	Blindy.	Tag	Tag	Temperature of Air—Degrees Fahrenheit.
	3	59	72	95	26	14	58	88	87				62	25	
Feb. 8, 8:30 A. M.....	1.0	1.4	1.2	1.9	1.4	1.5	1.6	0.8	1.0	1.4	1.1	0.5	1.2	1.5	.....
" " 9:00 "	1.1	1.1	0.9	2.1	1.8	1.9	1.6	0.6	99.7	0.8	1.0	99.9	0.9	0.8	42
" " 9:30 "	1.2	1.2	1.1	2.1	1.6	2.0	1.4	99.8	99.7	0.6	0.8	0.2	1.2	0.4	.....
" " 10:00 "	1.1	1.4	1.2	2.1	1.5	1.6	1.4	0.1	99.9	1.0	1.1	0.8	0.9	0.4	43
Water 10:30 "	0.4	0.5	0.5	1.3	1.0	1.3	1.2	0.5	0.6	0.6	1.5	0.5	1.5	0.4	.....
Feb. 8, 11:00 "	0.2	0.1	99.7	0.0	0.0	0.1	1.4	0.6	1.0	0.2	1.2	0.5	1.0	0.6	44
" " 11:30 "	0.2	0.1	0.3	0.0	0.5	0.4	0.5	0.5	0.6	0.4	1.1	0.6	1.4	0.8	.....
Fed 12:00 Noon.....	0.3	0.2	0.3	0.1	0.8	0.5	0.8	0.7	0.8	0.3	1.0	0.7	1.2	0.7	45
Feb. 8, 1:00 P. M.....	1.0	0.7	0.7	0.2	0.5	1.3	1.2	99.8	0.7	1.1	1.2	1.3	1.7	0.5	47
" " 1:30 "	1.0	1.0	0.5	0.2	0.4	1.3	1.2	0.0	0.4	1.0	0.7	1.2	1.5	0.6	.....
" " 2:00 "	0.6	0.9	1.0	0.3	0.6	1.5	1.0	99.9	0.5	0.6	0.5	0.7	1.6	0.8	.....
" " 2:30 "	1.0	1.2	0.5	0.5	0.7	1.3	1.1	0.3	0.7	1.0	0.4	0.8	1.7	0.7	.....
" " 3:00 "	1.2	1.2	0.4	0.5	0.4	1.1	1.3	0.6	0.6	1.1	1.0	0.7	1.4	0.8	45
" " 3:30 "	1.0	1.1	0.5	0.6	0.5	1.3	1.3	0.5	0.5	1.1	1.1	0.8	1.5	1.1	.....
" " 4:00 "	0.7	1.1	0.4	0.9	0.3	1.3	1.2	0.4	0.3	1.2	0.8	0.6	1.2	1.4	.....
Watered 4:30* " .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Feb. 8, 5:00 "	99.3	99.8	0.1	0.7	99.6	1.3	0.4	0.5	0.5	0.6	0.5	0.6	1.3	1.1	43
Fed 6:00 "	99.4	0.1	0.4	0.7	99.5	1.4	0.4	0.4	0.6	1.2	0.6	1.0	1.9	1.4	42
Feb. 8, 7:00 "	0.5	0.4	0.6	0.7	0.7	1.1	0.9	0.7	0.6	1.2	1.3	1.2	1.9	0.7	43
" " 7:30 "	0.8	0.7	0.8	1.2	0.5	0.3	0.5	0.7	1.1	0.9	0.8	1.1	1.3	0.7	.....
" " 8:00 "	0.5	0.6	0.7	0.7	0.5	1.1	1.1	0.9	1.0	1.1	0.7	1.3	1.1	0.8	.....
" " 9:00 "	0.9	1.2	0.4	0.9	0.4	1.1	0.4	0.3	0.8	1.1	0.9	0.3	1.7	0.7	44
" " 10:00 "	0.5	0.7	0.3	0.8	0.1	1.1	0.5	1.0	0.8	0.9	1.2	1.1	1.6	1.0	45.5
" " 12:00 Midnight	0.5	1.3	0.0	0.7	0.6	0.7	0.3	0.9	0.4	1.0	0.9	0.6	0.9	1.4	44
" 9, 2:00 A. M.....	0.7	0.8	0.4	1.1	0.4	0.4	0.8	0.8	0.4	0.7	0.6	0.6	1.7	0.4	43
" " 4:00 "	0.0	0.1	0.2	0.9	0.0	0.4	0.3	0.6	0.9	0.9	0.1	0.1	1.3	0.8	41
" " 5:00 "	0.1	0.4	99.9	0.7	99.9	0.2	0.2	0.0	0.2	0.6	0.1	0.1	1.1	1.1	40.5
" " 6:00 "	0.2	0.8	0.4	1.3	0.7	0.6	0.5	0.6	0.7	0.7	0.5	0.4	1.3	1.1	.....
" " 6:30 "	0.1	0.7	0.5	1.4	0.4	0.5	0.7	0.8	0.6	0.9	0.5	0.6	1.2	1.1	.....
Fed 7:00 "	0.4	0.8	0.7	1.4	0.6	0.6	0.7	1.0	0.6	1.2	0.4	1.0	1.5	1.4	41
Feb. 9, 7:30 "	0.5	1.0	0.7	1.7	0.7	0.8	0.9	0.8	0.5	1.1	0.7	1.1	1.5	1.0	.....

*93 and 14 did not drink.

TABLE 1.—Concluded.

Cow Temperatures, 1896.

(Temperatures above 100 degrees are indicated only by units and tenths.)

DATE AND HOUR.	Tag 3	Tag 59	Tag 72	Tag 95	Tag 26	Tag 14	Tag 58	Tag 88	Tag 87	Woodlawn.	Blanket.	Blindy.	Tag 62	Tag 25	Temperature of Air—Degrees Fahrenheit.
Feb. 9, 8:30 A. M.....	1.0	1.2	1.1	2.0	1.2	1.4	1.2	0.5	0.6	0.8	1.0	0.9	1.4	0.8	.....
" " 9:00 "	1.2	1.4	1.3	2.1	1.2	1.5	1.0	0.4	1.0	1.2	1.0	1.0	1.5	0.8	38
" " 9:30 "	1.5	1.8	1.8	2.3	1.5	1.8	1.3	0.2	0.9	1.2	0.7	1.1	1.6	1.1	.....
" " 10:00 "	1.5	1.9	1.2	2.2	1.4	1.7	1.4	0.5	1.0	0.9	1.0	1.1	1.7	1.1	37
" " 10:30 "	1.5	1.9	0.8	2.0	1.1	1.0	1.4	0.7	1.3	1.1	1.0	1.2	1.7	1.3	.....
Water 11:00 "	0.0	0.6	0.2	0.5	0.3	0.4	0.8	0.6	1.3	0.8	1.1	1.2	1.4	1.5	38
Feb. 9, 11:30 "	99.9	0.2	0.0	98.9	0.5	0.1	1.2	0.5	1.3	0.8	0.9	1.1	1.3	1.7	.....
Food 12:00 Noon.....	99.9	0.1	0.1	99.2	0.7	0.2	1.4	0.5	1.4	1.2	1.1	1.0	1.7	2.0	39
Feb. 9, 12:30 P. M.....	99.8	0.4	0.1	99.2	0.7	0.3	1.6	0.5	1.3	1.1	1.1	1.1	1.6	2.3	.....
" " 1:30 "	1.2	1.2	0.4	99.8	0.8	1.0	1.3	0.2	99.8	0.6	1.2	1.2	2.1	1.1	.....
" " 2:00 "	1.1	1.2	0.6	99.8	1.0	0.9	1.4	0.6	0.2	0.0	99.9	1.3	2.5	0.7	.....
" " 2:30 "	1.1	1.0	0.6	0.4	1.0	1.1	1.7	0.8	0.4	0.3	99.5	0.1	1.9	0.6	39.5
" " 3:00 "	1.3	1.3	0.8	0.5	1.4	0.9	1.6	1.1	0.8	0.7	0.5	0.6	1.3	1.2	.....
" " 3:30 "	0.8	1.3	0.7	0.2	0.9	1.1	1.1	0.1	0.2	0.5	0.6	0.6	1.4	1.4	42
" " 4:00 "	0.6	1.1	1.1	0.1	0.5	1.1	0.8	0.3	0.1	0.7	0.1	0.7	1.6	0.8	40
Water 5:00 "	99.1	99.9	99.1	99.2	99.1	99.3	98.3	0.0	0.2	1.0	0.5	1.1	1.9	1.2	.....
Feb. 9, 5:30 "	99.5	0.3	99.3	99.8	99.5	99.6	98.4	0.3	0.4	1.0	0.7	0.8	2.0	1.5	.....
Food 6:00 "	99.8	0.5	99.5	0.2	99.7	99.9	98.8	0.6	0.5	1.1	0.8	0.9	1.9	1.8	.....
Feb. 9, 7:00 "	99.8	0.6	0.2	0.8	0.5	0.5	99.7	0.8	0.5	1.1	0.5	0.7	2.1	1.5	.....
" " 7:30 "	0.1	0.7	0.3	0.8	0.5	0.6	99.8	0.6	0.4	1.1	0.6	0.8	1.8	1.3	.....
" " 8:00 "	0.5	1.0	0.3	0.8	0.4	0.9	0.0	0.8	0.2	1.1	0.8	0.6	1.5	1.5	40
" " 9:00 "	0.5	0.8	0.2	0.4	0.2	0.8	0.2	0.6	0.6	1.0	0.5	0.6	1.5	1.7	39.5
" " 10:00 "	0.7	0.8	0.0	0.7	0.4	0.4	0.2	0.6	0.4	0.8	0.6	0.6	1.4	2.0	39
" " 12:00 Midnight.....	0.4	0.5	99.8	0.7	0.1	0.5	0.6	0.4	0.5	1.1	0.4	0.6	1.3	2.3	38
" 10, 2:00 A. M.....	0.6	0.4	0.4	0.9	0.0	0.6	0.6	0.3	0.5	0.8	0.5	0.5	1.5	2.6	36
" " 4:00 "	0.4	0.2	0.1	0.5	0.4	0.4	0.6	0.7	0.6	1.1	0.2	0.6	1.3	2.3	35
" " 5:00 "	0.2	0.8	0.1	0.9	0.4	0.8	0.8	0.6	0.8	1.2	0.5	0.4	1.5	2.0	34
" " 6:00 "	0.2	0.8	0.3	1.1	0.3	0.5	0.6	0.3	0.4	0.8	0.5	0.5	1.3	2.0	.....
Food 7:00 "	0.6	0.9	0.2	1.2	0.4	0.8	0.5	0.2	0.6	1.2	0.6	1.0	1.4	2.1	35

NOTE.—The feeding and watering was completed at the hours indicated, before the temperatures of the respective hours were taken. The last five cows on the list had access to water at all hours.

TABLE 2.

Cow Temperatures, 1896—Morning and Evening.

(Temperatures above 100 degrees are indicated only by units and tenths.)

DATE AND HOUR.	Air Temperature—Degrees.	Tag 8	Tag 59	Tag 72	Tag 96	Tag 26	Tag 14	Tag 58
Feb. 11, 4:50 P. M.....	88	99.6	0.6	99.7	0.7	0.8	1.0	99.8
" " 5:40 "	85	99.5	0.6	0.0	0.8	0.7	1.0	99.2
" 14, 5:30 A. M.....	88	1.5	1.8	0.8	1.5	2.0	2.1	1.8
" " 6:40 "	85	0.7	1.7	1.8	1.9	1.7	1.9	1.5
" 15, 5:40 "	87	0.2	1.5	0.8	1.8	1.4	1.7	1.5
" " 6:40 "	85	0.0	1.4	1.2	2.1	1.4	1.6	1.5
" 16, 4:30 P. M.....	84	0.2	1.6	0.5	1.5	0.2	2.8	0.8
" " 5:30 "	80	0.2	1.5	0.7	1.5	0.6	2.7	0.6
" 17, 5:30 A. M.....	12	0.8	2.8	1.4	2.0	1.5	2.2	0.4
" " 6:30 "	8	0.0	1.6	0.7	1.4	1.0	2.0	0.2
" " 4:30 P. M.....	25	0.1	99.5	0.2	0.8	0.7	2.2	98.9
" " 5:40 "	23	99.8	99.5	0.8	0.9	0.6	2.0	99.0
" 18, 5:30 A. M.....	15	1.2	1.4	1.1	1.7	0.8	2.1	0.9
" " 6:40 "	17	0.9	1.0	1.2	1.6	1.0	2.1	1.1
" " 4:50 P. M.....	85	2.0	1.5	0.5	1.2	1.0	1.5	0.8
" " 5:40 "	84	2.4	1.4	0.4	1.5	1.3	1.6	0.4
" 19, 5:30 A. M.....	88	1.2	1.8	0.6	1.7	1.5	1.4	1.6
" " 6:40 "	84	1.0	1.4	0.4	1.9	1.3	1.5	1.4
" 20, 5:30 "	24	1.0	1.7	0.5	1.7	1.0	1.7	1.4
" " 6:30 "	24	0.8	1.6	0.7	1.5	0.8	1.5	1.4
" " 4:50 P. M.....	80	99.8	1.0	0.2	1.0	0.8	1.7	99.0
" " 5:40 "	26	99.7	1.0	0.8	0.9	0.6	1.9	99.0
" 21, 5:30 A. M.....	22	0.5	1.8	0.4	1.2	0.6	1.6	1.0
" " 6:30 "	19	0.8	1.6	0.8	1.4	0.8	1.6	0.7
" " 4:50 P. M.....	29	99.8	1.4	0.8	0.5	0.6	1.4	1.6
" " 5:40 "	27	99.7	1.5	0.1	0.6	0.6	1.5	1.7

See note at end of Table 2.

TABLE 2.—Continued.

Cow Temperatures, 1896—Morning and Evening.

(Temperatures above 100 degrees are indicated only by units and tenths.)

DATE AND HOUR.	Air Temper- ture—Degrees.	Tag 8	Tag 59	Tag 72	Tag 95	Tag 26	Tag 14	Tag. 58
Feb. 22, A. M.....	23	0.4	1.6	0.6	1.4	1.2	1.5	1.4
" " ".....	21	0.3	1.4	0.5	1.5	1.3	1.3	1.5
" 23, ".....	34	0.3	1.4	1.1	1.4	1.6	1.6	1.3
" " ".....	33	0.2	1.1	1.0	1.5	1.7	1.5	1.1
" 25, P. M.....	32	0.5	1.3	1.3	1.8	1.1	2.2	1.3
" " ".....	28	0.3	1.4	1.0	1.7	1.4	2.2	1.4
" 26, A. M.....	26	0.6	1.4	0.6	1.7	1.6	1.9	1.4
" " ".....	27	0.4	1.4	0.5	1.6	1.6	1.8	1.5
" " P. M.....	35	1.3	1.6	1.2	1.7	1.6	2.2	1.6
" " ".....	34	1.1	1.3	1.4	1.5	1.6	2.4	1.6
" 27, A. M.....	33	1.9	1.4	1.5	1.9	1.3	2.2	1.4
" " ".....	32	2.1	1.7	1.2	2.1	2.0	2.1	1.5
March 4, ".....	23	99.8	1.3	1.2	1.6	1.0	1.7	1.6
" " ".....	23	99.5	1.5	1.2	1.9	1.3	1.7	1.4
" 9, P. M.....	43	0.6	1.4	0.7	1.4	1.0	0.3	0.3
" " ".....	44	0.5	1.4	0.3	1.5	1.1	0.5	0.3
" 10, A. M.....	36	0.1	1.3	1.0	2.0	1.1	1.2	0.4
" " ".....	36	0.0	2.0	0.3	2.1	1.3	1.2	0.5
" " P. M.....	38	0.3	0.6	1.3	1.7	0.3	1.7	1.3
" " ".....	37	0.4	0.5	1.2	1.3	1.0	1.6	1.2
" 11, A. M.....	39	0.4	1.3	1.5	2.1	1.6	1.3	1.7
" " ".....	37	0.4	1.5	1.6	2.3	1.5	1.6	1.7
" " P. M.....	38	1.5	0.4	0.6	1.6	0.7	1.0	0.0
" " ".....	37	1.7	0.3	0.6	1.6	0.7	1.0	0.3
" 12, A. M.....	33	0.3	1.3	1.1	2.0	1.2	1.7	1.1
" " ".....	31	0.2	1.4	1.0	2.1	1.2	1.5	1.2
" " P. M.....	34	99.7	99.3	0.5	1.0	1.1	0.0	99.5
" " ".....	31	99.6	99.7	0.5	1.1	0.9	0.3	99.6
" 13, A. M.....	22	0.4	0.2	1.3	1.3	1.1	1.6	0.7
" " ".....	19	0.3	0.7	0.9	2.0	1.1	1.3	0.2
" " P. M.....	35	1.3	1.4	1.3	2.0	0.3	2.1	1.4
" " ".....	33	1.1	1.2	1.1	1.3	0.6	2.0	1.3

TABLE 2.—Continued

Cow Temperatures, 1896—Morning and Evening.

(Temperatures above 100 degrees are indicated only by units and tenths.)

DATE AND HOUR.	Air Temperature—Degrees.	Tag 8	Tag 59	Tag 72	Tag 95	Tag 26	Tag 14	Tag 58
March 14, A. M.....	22	0.0	1.4	1.2	2.0	0.5	1.7	1.0
" " "	19	0.2	1.5	1.1	2.2	0.6	1.6	1.1
" " P. M.....	39	0.7	1.0	0.7	2.0	0.9	1.6	1.6
" " "	33	0.5	1.6	1.2	1.8	1.0	1.8	1.4
" 15, A. M.....	29	0.0	1.1	1.0	2.0	1.8	1.8	0.8
" " "	26.5	0.1	1.1	0.8	2.1	1.7	1.8	1.0
" " P. M.....	33.5	0.3	0.7	0.9	1.9	1.1	2.1	1.0
" " "	38	0.4	0.9	0.9	1.7	1.0	2.0	1.2
" 16, A. M.....	40	0.5	2.0	1.5	2.3	1.5	1.8	1.3
" " "	37	0.4	1.8	1.7	2.4	1.5	2.0	1.7
" " P. M.....	37	0.1	0.3	0.5	1.5	0.4	1.1	1.2
" " "	33	0.5	0.1	0.1	1.3	0.6	1.3	1.5
" 17, A. M.....	36	2.2	1.6	0.9	2.4	0.8	1.9	1.7
" " "	34	2.2	1.6	1.3	2.5	1.0	1.6	1.7
" " P. M.....	41	0.0	0.4	0.8	1.6	0.2	0.7	0.8
" " "	39	0.0	0.2	0.6	1.5	0.5	0.7	1.1
" 18, A. M.....	32	99.6	1.2	0.6	2.1	0.3	1.7	1.6
" " "	29	99.5	1.0	0.7	2.2	0.1	1.6	1.8
" " P. M.....	40	0.2	1.9	1.3	1.7	0.7	2.3	1.0
" " "	40	0.1	1.6	1.0	1.7	1.0	2.0	1.1
" 19, A. M.....	43	0.4	0.3	1.2	1.2	0.5	1.3	0.5
" " "	42	0.5	1.0	0.4	1.1	0.3	1.0	0.4
" " P. M.....	56	0.2	0.2	0.8	0.8	0.5	1.3	0.6
" " "	56	0.2	0.2	0.5	1.0	0.5	1.0	1.1
" 20, A. M.*.....	44	0.1	0.9	0.6	1.3	0.5	1.3	1.5
" " "	41	0.1	0.9	0.7	1.3	0.3	1.2	1.2
" " P. M.....	43	0.2	0.4	0.7	0.8	0.7	1.4	0.1
" " "	40	0.0	0.4	0.8	0.8	0.5	1.4	0.4
" 21, A. M.....	27	99.8	0.4	0.2	0.9	0.4	0.8	0.3
" " "	27	99.8	0.3	0.1	1.2	0.3	0.7	0.1
" " P. M.....	47	0.0	99.7	0.2	0.5	0.1	0.9	0.3
" " "	45	0.4	0.0	0.2	0.5	0.4	1.1	1.1

* Used new thermometer from this henceforth.

TABLE 2.—Continued.

Cow Temperatures, 1896—Morning and Evening.

(Temperatures above 100 degrees are indicated only by units and tenths.)

DATE AND HOUR.	Air Temperature—Degrees.	Tag 8	Tag 59	Tag 72	Tag 95	Tag 26	Tag 14	Tag 58
March 22, A. M.....	89	2.0	0.7	0.1	0.7	0.1	0.6	0.8
" " ".....	88	2.5	0.5	0.2	1.1	0.2	0.6	0.7
" " P. M.....	57	0.2	0.7	0.8	1.4	1.1	2.5	1.9
" " ".....	56	0.4	1.0	0.8	1.5	1.4	2.5	2.1
" 23, A. M.....	35	99.8	0.6	0.7	0.8	2.0	1.0	0.5
" " ".....	38.5	99.9	0.7	0.6	0.9	1.8	1.1	0.3
" " P. M.....	38	0.0	0.2	1.5	0.6	3.0	1.2	1.4
" " ".....	32	99.9	0.4	1.5	0.5	3.2	1.4	1.1
" 24, A. M.....	25	0.0	1.8	1.5	0.5	1.6	2.8	0.5
" " ".....	23	0.4	1.6	1.5	0.4	1.9	3.0	0.4
" " P. M.....	40	0.4	0.0	0.4	0.8	0.2	2.6	0.1
" " ".....	37	0.8	99.8	0.4	1.0	99.8	2.7	99.8
" 25, A. M.....	23	0.4	0.2	0.3	0.6	0.9	2.4	0.6
" " ".....	22	0.2	0.2	0.2	0.5	1.3	2.1	0.3
" " P. M.....	51	0.1	0.3	2.5	0.7	1.7	1.9	1.7
" " ".....	49	0.0	0.7	2.2	0.8	1.5	1.7	1.7
" 26, A. M.....	48	0.0	0.6	0.3	1.3	0.5	1.0	1.6
" " ".....	47	0.3	0.3	0.2	0.2	0.3	0.8	1.4
" " P. M.....	63 {	0.7	1.1	99.8	0.9	1.0	2.2	1.1
	old 0.4	0.8	99.6	0.7	99.8	2.0	0.9*	
" " ".....	63 {	0.4	0.9	0.1	0.8	0.3	2.1	1.2
	old 0.2	0.7	99.9	0.6	0.1	1.9	1.0*	
" 27, A. M.....	26	0.5	1.5	0.4	0.8	0.0	1.1	0.6
" " ".....	27	0.7	1.1	0.1	0.7	0.0	1.3	0.3
" " P. M.....	41 {	3.1	0.1	1.0	99.8	0.4	1.3	0.6
	old 2.3	99.8	0.3	99.6	0.2	1.6	0.4*	
" " ".....	40	3.4	99.9	0.3	0.1	0.2	1.5	0.9
" 28, A. M.....	34	1.0	0.4	0.2	0.5	0.2	1.3	0.5
" " ".....	38.5	1.0	0.7	0.1	0.3	0.1	1.0	0.3
" " P. M.....	54	0.6	0.4	0.0	1.1	0.5	1.5	1.0
" " ".....	52	0.5	0.5	0.2	1.2	0.5	1.5	1.0

* This line of temperatures taken with old thermometer.

TABLE 2.—Continued.

Cow Temperatures, 1896—Morning and Evening.

(Temperatures above 100 degrees are indicated only by units and tenths.)

DATE AND HOUR.	Air Temper- ture—Degrees.	Tag 8	Tag 59	Tag 72	Tag 95	Tag 26	Tag 14	Tag 58
March 29, A. M.....	47	0.2	0.7	0.0	1.0	0.5	0.6	0.5
" " ".....	48	0.5	0.8	0.1	1.0	0.8	0.7	0.4
" " P. M.....	61	0.9	0.6	0.4	1.8	0.7	1.1	0.6
" " ".....	59	0.5	0.4	0.1	1.0	0.4	0.8	0.5
" 30, A. M.....	47	1.0	0.4	0.0	0.8	99.8	1.1	0.6
" " ".....	45	1.2	0.7	0.1	1.0	0.2	0.9	0.6
" " P. M.....	59	0.4	0.6	0.7	0.9	0.4	1.6	1.0
" " ".....	59	0.8	0.7	0.9	1.0	0.4	1.5	1.2
" 31, A. M.....	47	0.6	0.7	0.5	1.8	0.4	1.5	1.6
" " ".....	47	0.7	0.9	0.6	1.4	0.7	1.8	1.5
April 9, P. M.....	48	0.8	0.9	0.8	0.6	0.4	1.6	1.5
" " ".....	46	0.4	1.0	1.0	0.5	0.5	1.6	1.8
" 10, A. M.....	45	99.8	0.7	0.8	0.9	0.7	1.0	1.2
" " ".....	45	0.0	1.0	0.8	0.9	0.5	1.0	1.0
" " P. M.....	48	99.9	0.0	0.8	6.6	0.5	1.8	99.8
" " ".....	49	99.9	0.0	0.5	0.6	0.8	1.8	99.9
" 11, A. M.....	41.5	99.7	0.5	0.8	0.9	0.7	1.0	0.8
" " ".....	41.5	99.9	0.5	0.5	0.6	0.7	1.1	0.8
" " P. M.....	55	1.0	0.5	0.8	0.7	0.5	1.6	2.0
" " ".....	54	0.8	0.6	0.6	0.7	0.7	1.7	1.8
" 12, A. M.....	56	0.8	0.4	0.6	1.0	0.7	1.0	0.8
" " ".....	57	0.5	0.4	0.4	1.2	0.6	0.9	1.0
" " P. M.....	59	0.2	0.6	1.0	0.8	1.1	2.0	1.4
" " ".....	58	0.0	0.4	1.2	0.5	1.8	1.8	1.6
" 13, A. M.....	45	99.8	0.5	0.8	0.5	0.2	0.5	0.8
" " ".....	45	0.1	0.5	0.8	0.4	0.8	0.5	0.7
" " P. M.....	71	0.8	0.2	0.7	0.8	0.4	1.6	2.5
" " ".....	74	0.5	0.8	0.9	0.4	0.5	1.8	2.4
" 14, A. M.....	61	0.9	0.4	0.5	0.6	0.4	1.4	1.2
" " ".....	68	1.0	0.5	0.6	0.8	0.6	1.8	1.0
" " P. M.....	78	0.0	0.5	0.8	0.8	0.6	1.7	2.2
" " ".....	77	0.0	0.6	0.6	0.6	0.5	1.9	2.4

TABLE 2.—Continued.

Cow Temperatures, 1896—Morning and Evening.

(Temperatures above 100 degrees are indicated only by units and tenths.)

DATE AND HOUR.	Air Temperature—Degrees.	Tag 3	Tag 59	Tag 72	Tag 95	Tag 26	Tag 14	Tag 58
April 15, A. M.....	62	0.0	0.4	0.4	0.5	0.5	1.0	1.1
" " "	63	0.0	0.4	0.5	0.6	0.4	1.0	1.0
" " P. M.....	88	0.4	0.6	0.7	0.7	0.8	1.4	1.3
" " "	82	0.8	0.9	0.9	0.8	0.4	1.7	1.7
" 16, A. M.....	61	0.2	0.4	0.0	0.7	0.6	0.6	0.1
" " "	63	0.2	0.3	0.1	0.7	0.5	0.5	0.3
" " P. M.....	87	0.7	0.6	1.2	0.6	1.2	2.0	2.8
" " "	86	0.5	0.6	1.2	0.8	1.1	2.9	2.7
" 17, A. M.....	65	0.2	0.3	0.5	0.6	0.4	0.8	1.1
" " "	67	0.4	0.4	0.7	0.8	0.6	0.8	0.9
" " P. M.....	90	0.6	1.3	1.0	2.0	2.0	3.3	2.9
" " "	88	0.6	1.2	1.1	1.8	2.0	3.1	3.0
" 18, A. M.....	54	99.8	0.6	99.7	0.1	0.3	0.0	99.5
" " "	56	99.6	0.3	99.6	99.8	0.3	0.0	99.5
" " P. M.....	89	0.9	0.8	1.3	1.6	0.3	2.2	2.5
" " "	88	0.8	0.9	1.4	1.6	0.5	2.5	2.4
" 19, A. M.....	67	0.1	0.6	0.5	0.1	0.1	0.2	0.4
" " "	68	0.1	0.5	0.5	0.0	0.3	0.3	0.2
" " P. M.....	88	1.2	0.7	0.9	1.3	0.5	2.4	1.3
" " "	86	1.2	0.6	0.7	1.2	0.7	2.4	1.3
" 20, A. M.....	66	0.6	1.0	0.1	0.3	0.5	0.3	0.6
" " "	67	0.4	0.7	0.4	0.2	0.6	0.5	0.9
" " P. M.....	81	0.3	0.8	1.0	1.3	0.6	2.3	1.6
" " "	80	0.6	0.8	1.1	1.2	0.7	2.3	1.7
" 21, A. M.....	62	0.2	0.4	0.0	0.0	0.6	0.2	99.7
" " "	63	0.0	0.5	0.0	0.3	0.7	0.6	99.3
" " P. M.....	77	0.7	0.6	1.4	0.6	0.7	2.4	1.4
" " "	77	0.7	0.6	1.4	1.0	0.6	2.5	1.5
" 22, A. M.....	51	0.1	0.6	99.5	0.4	0.6	0.3	0.0
" " "	53	0.1	0.5	99.5	0.5	0.3	1.0	0.3
" " P. M.....	59	0.5	0.7	0.7	1.2	0.3	1.6	0.3
" " "	60	0.6	1.0	0.9	1.4	0.3	1.9	1.1

Table 2.—Continued.

Cow Temperatures, 1896—Morning and Evening.

(Temperatures above 100 degrees are indicated only by units and tenths.)

DATE AND HOUR.	Air Temperature—Degrees.	Tag 3	Tag 59	Tag 72	Tag 95	Tag 26	Tag 14	Tag 58
April 23, A. M.....	40	99.9	1.4	0.4	0.5	0.1	0.7	0.0
" " ".....	48	99.8	1.1	0.2	0.5	0.3	0.9	0.3
" " P. M.....	70	0.8	1.3	3.0	2.0	0.4	1.9	1.3
" " ".....	68	1.0	1.3	3.2	2.0	0.4	2.2	2.0
" 24, A. M.....	44	0.6	1.2	0.0	1.0	0.1	0.6	0.5
" " ".....	49	0.5	1.0	0.0	1.3	0.2	0.9	0.7
" " P. M.....	51	0.5	1.5	1.3	1.1	0.5	1.6	1.3
" " ".....	51	0.5	1.5	1.0	1.4	0.7	1.9	2.0
" 25, A. M.....	47	3.0	1.3	0.4	1.7	0.7	1.4	1.6
" " ".....	48	3.0	1.4	0.7	1.3	0.6	1.4	1.5
" " P. M.....	58	0.4	0.9	1.2	1.2	0.5	1.7	1.6
" " ".....	52	0.5	0.7	1.4	1.4	0.7	1.9	1.9
" 26, A. M.....	46	99.6	0.9	99.5	99.8	0.6	0.8	0.6
" " ".....	47.5	99.9	1.0	99.4	0.2	0.3	1.1	0.9
" " P. M.....	62	0.5	0.6	0.3	0.3	0.1	2.4	2.0
" " ".....	61	0.4	0.6	0.2	0.9	0.2	2.5	1.9
" 27, A. M.....	41	0.2	0.5	0.4	0.7	0.0	2.1	1.3
" " ".....	42	0.4	0.5	0.6	0.3	0.1	2.0	1.9
" " P. M.....	59	0.6	0.3	0.6	1.0	0.3	2.2	2.4
" " ".....	58	0.7	0.7	0.7	1.1	0.5	2.4	2.3
" 28, A. M.....	43	0.1	0.3	0.2	0.3	0.1	2.1	1.7
" " ".....	45	0.0	0.5	0.3	1.0	0.2	2.2	1.9
" " P. M.....	70	0.6	0.7	0.2	0.7	0.2	2.4	2.0
" " ".....	69	0.7	0.7	0.4	0.6	0.1	2.2	2.1
" 29, A. M.....	44	0.1	0.2	0.1	0.7	99.8	1.5	1.4
" " ".....	45	0.3	0.4	0.3	0.5	99.9	1.7	1.6
" " P. M.....	71	0.5	0.3	0.5	1.0	0.3	2.1	2.0
" " ".....	69	0.7	1.0	0.7	1.1	0.4	2.0	2.1
" 30, A. M.....	49	99.9	0.3	99.7	0.1	0.2	1.3	1.3
" " ".....	51	99.9	0.5	99.9	0.2	0.4	1.7	1.6
" " P. M.....	76	0.4	0.9	0.4	0.3	0.7	1.9	1.3
" " ".....	75	0.6	1.1	0.6	0.9	0.5	2.2	1.7

TABLE 2.—Continued.

Cow Temperatures, 1896—Morning and Evening.

(Temperatures above 100 degrees are indicated only by units and tenths.)

DATE AND HOUR.	Air Tempera- ture—Degrees.	Tag 8	Tag 59	Tag 72	Tag 95	Tag 26	Tag 14	Tag 88
May 1, A. M.....	49	99.8	0.2	0.1	99.9	99.7	1.4	1.4
" " ".....	51	0.0	0.5	0.4	0.1	99.7	1.4	1.5
" " P. M.....	77	0.4	1.1	0.7	0.7	0.7	2.2	2.0
" " ".....	76	0.6	1.8	1.0	1.0	0.5	2.8	2.1
" 2, A. M.....	58	0.4	0.5	0.8	0.6	0.1	0.9	1.2
" " ".....	59	0.6	0.6	0.4	0.8	0.8	1.2	1.5
" " P. M.....	79	0.8	0.3	0.9	0.7	0.6	1.8	2.1
" " ".....	78	0.7	0.9	1.0	0.9	0.7	1.9	2.0
" 3, A. M.....	52	0.1	99.8	0.1	0.2	0.2	1.2	1.2
" " ".....	54	0.8	99.9	0.8	0.4	0.2	1.4	1.5
" " P. M.....	80	0.6	0.5	0.7	0.6	0.6	2.0	1.9
" " ".....	78	0.7	0.7	0.9	0.8	0.7	2.2	2.2
" 4, A. M.....	49	99.9	0.2	0.0	0.1	0.0	1.6	1.7
" " ".....	50	0.0	0.2	0.2	0.8	0.8	1.5	1.6
" " P. M.....	69	0.6	0.8	0.8	0.5	0.5	1.8	1.8
" " ".....	68	0.5	0.8	1.0	0.5	0.6	1.9	2.0
" 5, A. M.....	45	0.2	0.1	0.8	0.1	0.0	1.1	0.9
" " ".....	47	0.4	0.4	0.2	0.1	0.2	1.4	0.9
" " P. M.....	69	0.8	0.5	0.5	0.8	0.4	1.8	1.4
" " ".....	67	0.7	0.7	0.7	0.7	0.6	2.0	1.5
" 6, A. M.....	46	0.2	0.2	99.9	0.0	99.8	0.8	1.8
" " ".....	47	0.4	0.4	0.1	0.8	0.0	1.0	2.0
" " P. M.....	72	0.6	0.4	0.7	0.6	0.8	1.4	1.6
" " ".....	71	0.7	0.6	0.8	0.8	0.6	1.6	1.5
" 7, A. M.....	42	0.1	99.8	0.0	99.9	0.2	0.2	0.8
" " ".....	48	0.4	0.0	0.2	0.2	0.4	0.5	0.9
" " P. M.....	65	0.2	0.6	1.5	0.5	0.2	8.8	1.2
" " ".....	68	0.4	0.8	1.6	0.6	0.5	8.8	1.5
" 8, A. M.....	42	99.7	0.5	99.8	99.8	99.7	0.4	0.6
" " ".....	44	0.0	0.4	0.0	99.8	0.0	0.7	0.7
" " P. M.....	66	1.0	0.7	1.4	1.8	0.6	8.0	2.2
" " ".....	65	1.8	1.0	1.7	1.4	0.7	8.0	2.4

TABLE 2.—Concluded.

Cow Temperatures, 1896—Morning and Evening.

(Temperatures above 100 degrees are indicated only by units and tenths.)

DATE AND HOUR.	Air Tempera- ture—Degrees.	Tag 8	Tag 59	Tag 72	Tag 95	Tag 26	Tag 14	Tag 58
May 9, A. M.....	52	99.7	0.6	99.8	0.0	0.4	0.0	0.8
" " "	55	0.0	0.4	0.1	0.1	0.3	0.3	0.9
" " P. M.....	90	0.5	0.7	0.9	0.9	0.5	1.5	1.5
" " "	89	0.8	1.0	1.1	1.2	0.4	1.8	1.8
" 10, A. M.....	69	0.2	0.0	0.2	0.3	0.2	0.3	1.0
" " "	78	0.2	0.3	0.4	0.7	0.4	1.1	1.2
" " P. M.....	90.5	0.6	0.4	0.8	0.5	0.4	2.0	1.5
" " "	89	0.8	0.5	1.0	0.6	0.6	2.1	1.6
" 11, A. M.....	68	0.0	0.0	0.4	0.5	0.3	0.6	0.6
" " "	70	0.2	0.3	0.5	0.6	0.6	0.9	0.9
" " P. M.....	75	0.5	0.5	1.3	0.6	0.6	1.6	0.8
" " "	78	0.8	0.5	1.2	0.7	0.7	1.6	1.1
" 12, A. M.....	60	0.2	0.5	0.0	0.3	1.4	0.7	1.0
" " "	65	0.4	0.3	0.1	0.3	1.8	0.8	0.8
" " P. M.....	76	4.5	1.0	0.9	1.0	0.8	1.5	1.5
" " "	77	4.4	1.0	1.1	1.0	0.4	1.7	1.8
" 13, A. M.....	60.5	99.9	0.5	99.8	0.3	0.0	0.5	0.6
" " "	62	99.7	0.3	99.7	0.2	0.0	0.7	0.9
" " P. M.....	71.5	0.3	0.6	1.0	1.0	0.7	1.5	1.7
" " "	70	0.5	0.8	1.3	1.0	0.5	1.5	1.5
" 14, A. M.....	56	0.0	0.3	99.7	0.0	0.2	0.0	0.6
" " "	58	0.0	0.2	99.7	0.0	0.2	0.3	0.5
" " P. M.....	71.5	0.5	0.6	0.9	1.1	0.4	1.5	1.4
" " "	71	0.6	0.9	1.0	1.3	0.6	1.8	1.5
" 15, A. M.....	62	0.4	0.5	0.0	0.7	0.2	1.5	1.1
" " "	63	0.5	0.5	0.3	0.6	0.2	1.7	1.2
" " P. M.....	76	0.5	0.7	0.4	1.0	0.4	1.6	1.4
" " "	75	0.6	0.5	0.5	1.1	0.6	1.7	1.5
" 16, A. M.....	57	0.6	0.3	0.5	0.4	0.7	0.9	0.6
" " "	59	0.5	0.3	0.4	0.5	0.7	1.2	0.6

NOTE.—All temperatures of Table 2 were taken before and after milking, morning and evening, as see first page of Table 2 for the hours.

TABLE 3.

Cow Temperatures, May, 1896—Herd Injected.

(Temperatures above 100 degrees are indicated only by units and tenths.)

DATE AND HOUR.	Tag 8	Tag 59	Tag 72	Tag 95	Tag 26	Tag 14	Tag 58	Air Temperature—Degrees.
No. of Injection.....	9th.	8th.	8th.	8th.	10th.	10th.	7th.	
Minims Injected.....	25	20	33	25	25	25	25	
Weight—Pounds.....	965	925	1,210	925	980	1,135	920	
May 16, 10:00 A. M. (inj. made).....	0.4	0.7	0.7	0.8	1.1	1.6	0.6	78
“ “ 10:30 “	0.6	0.6	0.9	0.7	1.0	1.7	0.7	79
“ “ 11:00 “	0.5	0.5	0.7	0.8	0.9	1.5	0.9	80
“ “ 11:30 “	0.5	0.4	0.6	0.7	0.8	1.4	1.1	80
“ “ 12:00 Noon	0.4	0.3	0.6	0.8	0.6	1.4	1.1	81
“ “ 12:30 P. M.	0.4	0.5	0.6	0.7	0.4	1.5	0.9	81
Fed hay 1:00 “	0.7	1.0	0.9	1.1	0.4	1.5	1.2	82
May 16, 1:30 “	0.5	1.0	0.8	1.1	0.2	1.5	1.4	82
“ “ 2:00 “	0.8	1.2	0.9	1.0	0.1	1.6	1.5	83
“ “ 2:30 “	0.9	1.4	1.0	1.1	0.3	1.6	1.4	84
“ “ 3:00 “	1.0	1.2	1.2	1.2	0.3	1.6	1.6	83.5
Water 3:30 “	0.8	0.9	1.2	1.2	0.3	1.5	1.2	83
May 16, 4:00 “	0.6	0.7	1.4	0.8	0.2	1.2	0.9	84
“ “ 4:30 “	0.3	0.6	1.3	0.9	0.4	1.6	0.8	82
“ “ 5:00 “	0.2	0.6	1.3	0.7	0.2	1.7	0.9	81
“ “ 5:30 “	0.3	0.7	1.9	0.8	0.0	1.6	1.2	80.5
Fed “ 6:00 “	0.7	1.3	2.3	1.4	0.2	2.3	1.9	80
May “ 6:30 “	1.0	1.2	2.6	1.7	0.1	2.6	2.5	79.5

TABLE 3.—Concluded.

Cow Temperatures, May, 1896—Herd Injected.

(Temperatures above 100 degrees are indicated only by units and tenths.)

DATE AND HOUR.	Tag 8	Tag 59	Tag 72	Tag 95	Tag 25	Tag 14	Tag 58	Air Temperature—Degrees.
No. of Injection.....	9th.	8th.	8th.	8th.	10th.	10th.	7th.	
Minims Injected.....	25	20	38	25	25	25	25	
Weight—Pounds.....	965	925	1,210	925	980	1,185	920	
May 16, 7:00 P. M.....	0.4	0.6	2.6	1.8	0.0	2.5	2.7	75
“ “ 7:30 “	0.6	0.2	2.7	1.7	0.1	2.7	2.4	72
“ “ 8:00 “	1.8	1.0	2.4	2.8	0.6	2.6	2.7	72
“ “ 9:00 “	1.8	1.6	2.5	3.0	0.4	3.4	3.1	68
“ “ 10:00 “	1.5	2.1	2.4	3.2	0.5	2.6	2.4	67
“ “ 11:00 “	1.0	2.1	2.5	3.1	0.3	2.6	2.2	65
“ “ 12:00 Midnight.....	0.8	2.1	1.8	3.3	0.6	2.6	2.6	64
“ 17, 2:00 A. M.....	0.4	3.4	1.6	2.4	0.3	1.5	2.7	63
“ “ 4:00 “	0.3	4.2	0.7	0.9	0.6	1.8	2.2	61
“ “ 5:00 “	0.4	4.0	0.5	0.6	0.2	1.2	1.6	61
“ “ 6:00 “	0.0	3.5	0.6	0.6	0.1	1.2	1.4	63
Fed “ 6:30 “	0.3	3.1	0.5	0.6	0.2	0.9	1.6	64
Fodder 7:00 “	0.6	2.7	0.7	0.9	0.4	1.4	2.0	64
May 17, 7:30 “	0.8	3.0	1.1	1.2	0.7	1.8	1.8	65
“ “ 8:00 “	0.8	3.4	0.8	1.5	0.8	2.1	1.6	69
“ “ 8:30 “	0.8	3.2	1.1	1.5	0.8	2.3	1.5	72
“ “ 9:00 “	1.0	3.4	1.3	1.3	1.1	2.2	1.3	74
“ “ 9:30 “	1.3	3.5	1.5	1.4	1.5	2.4	1.4	74
“ “ 10:00 “	1.5	3.6	1.3	1.3	1.5	2.2	1.3	75

TABLE 4.

Cow Temperatures, June, 1896—Herd Injected.

(Temperatures above 100 degrees are indicated only by units and tenths.)

DATE AND HOUR.	Tag 8	Tag 59	Tag 72	Tag 95	Tag 26	Tag 14	Tag 58	Tag 4	Tag 15	Air Temperature— Degrees.
No. of Injection.....	10th.	9th.	9th.	9th.	11th.	11th.	8th.	1st.	1st.	
Minims Injected.....	25	20	38	25	25	25	50	...	...	
June 29, 5:30 P. M. (inj. made)...	1.6	1.9	2.3	2.0	1.2	2.9	1.9	1.2	2.7	82
" " 6:00 "	1.4	1.7	2.0	2.2	1.1	2.7	2.0	1.8	2.5	81
" " 7:00 "	0.8	1.2	1.5	1.6	0.9	2.3	1.8	1.8	2.2	78
" " 8:00 "	0.9	1.2	1.0	1.2	0.6	1.8	1.7	1.2	2.5	78.5
" " 9:00 "	0.8	0.7	0.7	1.1	0.5	1.5	1.5	1.0	2.5	72
" " 10:00 "	0.8	0.9	0.9	1.1	0.6	1.8	1.6	1.0	2.6	71
" " 12:00 Midnight.....	0.8	1.6	0.7	1.6	0.6	1.4	2.4	0.5	2.2	67
" 30, 2:00 A. M.	0.6	0.8	1.2	1.1	0.5	1.1	1.4	0.6	1.8	68
" " 4:00 "	0.9	1.0	1.2	1.4	0.5	1.1	0.9	0.7	1.1	60
" " 5:00 "	0.2	0.7	0.8	1.1	0.8	1.2	0.8	0.4	0.7	58.5
Fed " 6:00 "	0.8	0.9	1.2	1.4	0.7	1.4	0.8	0.2	0.6	61.5
June " 6:30 "	0.4	1.0	1.0	1.2	0.6	1.2	0.8	0.4	1.0	64
" " 7:00 "	0.5	0.6	1.2	1.0	0.5	1.3	0.5	0.4	1.2	66
" " 7:30 "	0.7	0.6	1.1	1.0	0.5	1.5	0.7	0.5	1.1	66
" " 8:00 "	0.5	0.7	1.0	1.0	0.2	1.2	0.6	1.0	1.6	68
" " 8:30 "	0.7	0.7	0.9	0.9	0.2	1.4	0.6	1.0	1.8	68
" " 9:00 "	0.5	1.0	0.8	0.9	0.5	1.6	0.9	0.6	1.2	69

TABLE 4.—Concluded.

Cow Temperatures, June, 1896—Herd Injected.

(Temperatures above 100 degrees are indicated only by units and tenths.)

DATE AND HOUR.	Tag 8	Tag 59	Tag 72	Tag 95	Tag 25	Tag 14	Tag 58	Tag 4	Tag 15	Air Temperature— Degrees.
No. of Injection.....	10th.	9th.	9th.	9th.	11th.	11th.	8th.	1st.	1st.	
Minims Injected.....	25	20	33	25	25	25	50	...	...	
June 30, 9:30 A. M.*	0.5	1.2	0.5	1.0	0.4	1.5	0.5	0.4	0.9	70
" " 10:00 "	1.0	1.3	0.5	0.7	0.4	1.2	0.5	0.8	0.8	71
" " 11:30 "	1.0	1.5	0.4	1.0	0.8	1.2	0.5	0.4	1.0	72
" " 11:00 "	1.0	1.9	0.4	1.0	0.8	1.1	0.6	0.5	1.3	73
" " 11:30 "	1.2	2.1	0.5	0.9	0.6	1.1	0.2	1.0	1.9	75
" " 12:00 Noon	1.3	2.4	0.5	0.7	0.4	1.2	0.2	0.7	1.6	75
" " 12:30 P. M.	1.3	3.0	0.4	1.0	0.8	1.2	0.5	0.5	1.4	75
" " 1:00 "	1.3	3.3	0.4	0.9	0.1	1.4	0.6	0.7	1.3	75
" " 1:30 "	2.0	3.6	0.4	1.0	0.2	1.4	0.9	1.0	1.3	76
" " 2:00 "	2.3	4.0	0.4	1.2	0.3	1.2	0.7	1.0	1.7	77
" " 2:30 "	3.0	4.1	0.5	1.1	0.4	1.2	0.8	1.0	1.5	78
" " 3:00 "	3.3	4.3	0.7	1.1	0.3	1.3	0.8	0.7	1.9	78
" " 3:30 "	4.0	4.7	0.8	1.0	0.4	1.4	0.9	1.0	2.0	80
" " 4:00 "	4.0	4.8	0.7	0.9	0.5	1.4	0.9	1.5	2.4	79
" " 4:30 "	4.2	4.4	1.0	1.4	1.0	2.0	1.5	1.8	2.7	80
Fed " 5:00 "	4.5	4.5	1.4	1.8	0.9	2.1	2.0	1.3	2.6	78.5
June " 5:30 "	4.6	4.3	2.0	1.9	0.8	2.2	2.2	1.4	2.5	77

*Cows watered; only 72 and 14 drank.

TABLE 5.

Cow Temperatures, August, 1896—Herd Injected.

(Temperatures above 100 degrees are indicated only by units and tenths.)

DATE AND HOUR.	Tag 8	Tag 59	Tag 72	Tag 96	Tag 26	Tag 14	Tag 58	Air Temperature— Degrees.
No. of Injection.....	11th.	10th.	10th.	10th.	12th.	12th.	9th.	
Minims Injected.....	30	25	27	26	25	30	42	
Aug. 22, 4:30 P. M. (inj. made).	1.4	1.0	1.6	1.9	1.0	1.7	4.5	.....
Fed " 5:00 "	1.7	1.3	1.7	1.9	1.0	1.8	4.5	76
Aug. " 5:30 "	2.0	1.8	2.0	2.2	1.8	2.2	4.5	.....
" " 6:00 "	2.3	2.1	2.0	2.5	1.8	2.5	4.3	.....
" " 7:00 "	2.5	1.8	2.0	2.5	1.2	2.5	4.7	74
" " 8:00 "	2.3	1.6	2.2	2.5	1.4	2.7	5.0	.....
" " 9:00 "	2.0	1.8	2.5	2.5	1.2	2.5	5.2	72
" " 10:00 "	1.7	1.9	2.1	2.6	1.1	2.8	5.5	.....
" " 12:00 Midnight.....	1.4	2.2	2.4	2.6	0.9	2.0	4.5	72
" " 2:00 A. M.	1.4	2.3	2.0	2.1	0.4	2.2	4.5	.....
" " 4:00 "	1.0	2.0	1.3	1.6	0.3	2.1	3.5	72
" " 5:00 "	0.5	1.5	0.7	1.0	0.5	1.7	3.0	.....
Fed " 6:00 "	1.0	0.9	0.8	1.1	0.3	1.5	2.4	72
Aug. " 6:30 "	1.0	1.3	1.4	1.5	0.6	1.8	2.2	.....
" " 7:00 "	1.2	1.7	1.5	2.0	0.8	2.2	2.2	73
" " 7:30 "	1.1	2.0	1.5	1.9	0.6	2.2	2.1	.....
" " 8:00 "	1.2	1.6	1.4	1.8	0.7	2.2	2.3	74
" " 8:30 "	1.2	2.0	1.3	2.0	0.7	2.1	2.0	.....
Water 9:00 "	1.2	3.0	1.4	1.3	0.6	2.0	1.7	.....

TABLE 5.—Concluded.

Cow Temperatures, August, 1896—Herd Injected.

(Temperatures above 100 degrees are indicated only by units and tenths.)

DATE AND HOUR.	Tag 3	Tag 59	Tag 72	Tag 95	Tag 26	Tag 14	Tag 58	Air Temperature— Degrees.
No. of Injection.....	11th.	10th.	10th.	10th.	12th.	12th.	9th.	
Minims Injected.....	80	25	27	25	25	30	42	
Aug. 23, 9:30 A. M.....	1.0	3.4	1.2	1.6	0.5	1.5	1.4	78
“ “ 10:00 “	1.1	3.5	1.2	1.1	0.3	1.2	1.0	.....
“ “ 10:30 “	1.2	4.5	1.0	1.2	0.3	1.0	0.7	.....
“ “ 11:00 “	1.3	4.8	1.3	1.2	0.3	1.0	0.8	79
“ “ 11:30 “	1.3	5.3	1.4	1.2	0.2	1.1	0.8	.....
“ “ 12:00 Noon.....	1.5	5.5	1.4	1.2	0.3	1.4	1.1	81
“ “ 12:30 P. M.....	1.4	5.5	1.4	1.3	0.1	1.3	1.2	.....
“ “ 1:00 “	1.5	5.4	1.3	1.4	0.2	1.5	1.3	.....
“ “ 1:30 “	1.8	6.0	1.5	1.3	0.4	1.6	1.7	83
“ “ 2:00 “	1.6	6.0	1.5	1.2	0.4	1.3	1.6	.....
“ “ 2:30 “	2.0	6.1	1.4	1.4	0.2	1.5	1.9	.....
“ “ 3:00 “	2.0	6.0	1.3	1.2	0.4	1.5	2.3	84
“ “ 3:30 “	2.1	6.0	1.7	1.5	0.6	1.4	2.0	.....
“ “ 4:00 “	2.0	5.3	1.6	1.6	0.9	1.7	2.0	84

TABLE 6.

Cow Temperatures, 1896.

Tuberculin Tests of New Additions to College Herd.

DATE AND HOUR.	Tag 27.	Tag 28.	Tag 29.	Heifer.
September 26, 5:30 P. M. (injection made).....	101.2	100.9	101.1	102.3
" " 6:00 "	101.4	101.0	101.1	102.7
" " 7:00 "	101.7	101.5	101.3	102.7
" " 8:00 "	101.3	101.2	100.8	102.4
" " 9:00 "	100.8	100.7	100.5	102.7
" " 10:00 "	100.7	100.5	100.5	102.5
" " 12:00 Midnight.....	101.5	100.6	100.4	102.6
" 26, 9:00 A. M.....	101.1	100.5	100.2	102.5
" " 4:00 "	100.8	100.7	100.4	102.5
" " 5:00 "	100.7	100.4	100.1	102.8
" " 6:00 "	100.8	100.5	100.4	102.3
" " 7:00 "	101.0	100.8	100.7	102.2
" " 7:30 "	100.6	100.5	100.7	101.7
" " 8:00 "	100.7	100.7	100.6	101.5
" " 8:30 "	101.3	101.2	100.8	101.8
" " 9:00 "	101.3	101.1	101.0	101.7
" " 9:30 "	101.0	101.0	100.9	102.0
" " 10:00 "	100.8	100.6	101.1	102.0
" " 10:30 "	100.7	100.8	101.0	101.9
" " 11:00 "	100.6	100.8	100.6	102.0
" " 11:30 "	101.0	101.0	101.1	101.8
" " 12:00 Noon.....	101.0	100.7	100.8	101.9
" " 1:00 P. M.....	101.1	100.5	100.9	102.5
" " 1:30 "	101.0	100.6	100.9	102.1
" " 2:00 "	101.2	100.6	100.7	102.2
" " 2:30 "	101.1	100.8	100.9	102.1
" " 3:00 "	101.0	100.9	100.9	101.8
" " 3:30 "	101.3	100.8	100.9	102.1
" " 4:00 "	101.5	100.9	100.9	102.5
" " 5:00 "	101.0	100.0	100.6	101.9
" " 5:30 "	101.3	100.9	100.9	102.2

TABLE 7.

Showing the Number of Germs in a Drop of Milk as Freshly Drawn from the Udder, with Precautions Against Outside Contamination, Milk from the Four Teats Kept Separate.

No. of Spurt...	1st.	2d.	3d.	4th.	5th.	6th.	7th.	8th.	9th.	Sum.	Average per Drop of All Milk Drawn.
Tag 2.	1,000	145	100	140	220	20	20	400	20	540	180
Tag 59.	45	25	40	40	80	260	80	800	80	2,280	1,825
Tag 72.	?	100	60	140	220	20	20	200	?	285	165
Tag 96.	15	75	20	40	40	140	40	?	?	520	40
Tag 26.	2,000	465	1,920	980	420	460	520	400	220	9,180	3,705
Tag 14.	50	40	60	440	40	100	60	?	?	800	180
Tag 58.	800	20	140	20	60	?	?	?	?	1,005	680
A	B	July 14.	July 25.	July 30.	August 1.	August 4.	August 14.	August 15.	August 17.	August 20.	Tests: left front, right front, left hind, right hind.
C	D										

A, left front test; B, right front test; C, left hind test; D, right hind test.

TABLE 8.

Showing the Number of Germs per Drop of the Milk of Cow 26,
Taken September 2d, 1896, at 4 P. M.

NO. OF SPURT.	TEAT B.			TEAT C.		
	Amount in Each Spurt.	Total Amount in Spurts Drawn.	No. of Germs per Drop.	Amount in Each Spurt.	Total Amount in Spurts Drawn.	No. of Germs per Drop.
1st.....	5 c.c.	5 c.c.	10,540	2 c.c.	2 c.c.	11,900
3d.....	8 "	18 "	4,420	3 "	9 "	2,040
5th.....	10 "	36 "	2,880	3 "	14 "	1,580
7th.....	6 "	49 "	1,860	2 "	20 "	1,140
9th.....	9 "	65 "	2,560	4 "	27 "	980
11th.....	9 "	85 "	480	5 "	36 "	740
13th.....	8 "	108 "	220	2 "	48 "	720
15th.....	5 "	114 "	520	3 "	50 "	940
17th.....	11 "	133 "	440	4 "	58 "	1,240
19th.....	7 "	155 "	880	4 "	65 "	620

One quart of milk equals 946 c.c.; 17,000 drops equal one quart.

III.

THE SUPPRESSION AND PREVENTION OF TUBERCULOSIS OF CATTLE AND ITS RELATION TO HUMAN CONSUMPTION.

INTRODUCTORY.

"Tuberculosis" is the scientific, "consumption" the popular term for a disease which exceeds all other diseases in the extent of its prevalence and fatality. Human beings, domesticated and captive animals, are alike subject to it, and it is transmissible from one individual to another. Scientific investigators, with considerable promise of success, are seeking a remedy for this greatest of plagues. Already we have gained sufficient knowledge of the cause and development of this disease to enable us to prevent its appearance or to suppress it. The principles to be applied are not entirely new; similar measures have succeeded when directed to the suppression or prevention of other diseases.

"Prevention is better than cure;" even though we possessed an infallible cure for this disease, we should avoid exposing ourselves to the danger of contracting this malady. It behooves us to learn of the nature of tuberculosis and the measures necessary to its prevention. Fortunately, owing to the peculiar manner in which consumption spreads, each individual has it in his power to keep himself and his cattle free from attack, even though his neighbor be negligent of his own interest.

From an economic standpoint the farmer and dairyman should keep their herds free from this insidious disease, but it is principally for man's sake that the lower animals should be included in the general scheme for freeing our country from this evil.

While this is mainly addressed to cattle-owners, and is on the subject of bovine tuberculosis, it would greatly weaken its force were a consideration of data bearing on human consumption omitted.

Owing to the general distribution and slow development of this disease, we do not show so great a concern about its presence as we do when a plague from a foreign shore visits our country. As in this

case the fatalities are crowded into a few weeks, the public attention is aroused, panic ensues and extreme measures are applied. If half as much care were exercised in regard to tuberculosis, this disease would disappear within a generation.

It is of primary importance that the public should realize that consumption is a plague greater than all other plagues combined.

DEATH-RATE OF CONSUMPTION (HUMAN AND BOVINE).

If all who die of consumption in New York City could be saved and placed in cities by themselves, each year a new city of nearly 6,000 inhabitants would be created.

In the State of Wisconsin, in 1891-92, there were 3 deaths from small-pox, 405 from typhoid fever, 415 from scarlet fever, 1,781 from diphtheria, 2,700 from consumption.

In Massachusetts, in 1885, one-sixth of all deaths were caused by consumption. Circular 83 of the New Jersey State Board of Health states that in New Jersey, in 1894, there were 30,000 deaths from consumption, or one-seventh (14 per cent.) of all deaths. Among the reservation Indians, in prisons and in cloisters the proportion of deaths from consumption ranges from one-half to four-fifths.

Among cattle, we do not have so full statistics, and indeed few animals are allowed to die a natural death. Veterinarians, however, know of many specific instances, and often are they called upon to condemn animals that are in the last stages of consumption. Many of these find their way to the soap and fertilizer factories. One factory reported that three-fourths of the carcasses received were tuberculous.

In the report for 1894 of the New York State Board of Health, a case is referred to of one farmer having lost 10 head of cattle from tuberculosis during the previous seven years. Another farmer lost over 100 during seventeen years.

In the report of the Iowa State Veterinarian for 1895 is given a case of the loss of 6 out of a herd of 41 animals during one summer, and another case of 5 out of 28 in three months.

It is well known that a number of large herds have been practically destroyed after condemnation by means of the tuberculin test.

PROPORTION OF TUBERCULOUS COWS LIVING.

We shall first consider statistics secured by slaughter-house or meat inspection; next those based on veterinary inspection previous to 1890, when tuberculin, as a diagnostic agent for tuberculosis, was introduced, and finally data secured by the more thorough and recent methods of diagnosis.

As regards meat inspection, it must be observed that animals designed for beef belong to a different class from dairy and stall-fed animals, and it has been ascertained that the latter are far more affected by tuberculosis than the former. Statistics from meat inspection will vary as the proportion of the carcasses from the two sources varies.

In Munich 2.5 per cent. of the carcasses were tuberculous, distributed as follows: Calves .0006, steers .73, cows 5.3 per cent. Taking the cows alone, the percentages increase with age, thus: Yearlings, .2; three to six years old, 33; older than six years, 59, or more than half, were tuberculous.

Other German cities report from 1 per cent. to 3.2 per cent. (Berlin). In Saxony the figures are as follows: Cows, nearly 7 per cent.; steers, 3.6 per cent.; bulls, 2.6 per cent.; calves, 1 per cent.

In Leipzig a high percentage of tuberculosis was found, viz., cows, 26 per cent.; bulls, 15.4 per cent.; calves, 9.3 per cent. The average for Germany is between 6 and 7 per cent.

In England the average is 12 per cent., based on figures ranging for different localities from 1 to 26 per cent.

In France but half a per cent. of tuberculosis has been reported; contrast this with 34 per cent. in Mexico.

In our own country statistics of this sort are very few. Three per cent. of tuberculosis was found by meat inspectors at Baltimore.

On the other hand, we possess some data given by veterinarians. These are based on "condemned" cases, but as a large proportion of "suspected" animals must also have been tuberculous, it is evident that the figures are below the real truth. However, allowance must be made for the fact that only extraordinarily-infected herds were examined.

In Massachusetts 1887-88, in 34 herds 28 per cent. of the animals were condemned. In 1890, the reports of 39 veterinarians in 17 States gave an average of 18 per cent. condemned.

Under the Koch test almost all the animals affected with tubercu-

losis can be discovered. This test has been widely applied, but as the worst herds were treated first, the percentages of tuberculosis thus secured have invariably been highest at first and have gradually fallen as more and more animals have been tested.

Professor Bang, of Denmark, reports that he found 38.7 per cent. of tuberculosis in 53,803 cases tested, but that the large herds included, were twice as much infected as the smaller herds.

In New York State, in 14 counties there were 656 condemnations out of 6,135 tested animals (11 per cent.), but in 5 other counties, only 184 out of 20,992, or less than 1 per cent., which proportion, Professor Law thinks, may nearly represent the true average for the whole State. Yet, in cities the percentage ranges from 5 to 98 per cent.

It is evident that the legislator is interested in knowing the extent of tuberculosis for the entire State; but the milk consumer is interested in knowing the percentage of tuberculosis in the locality whence he secures his milk.

Director Hills, of the Vermont Experiment Station, found 20 per cent. of tuberculosis when only a thousand cases had been tested, or omitting the two worst herds, about 7 per cent. When the number of cases tested in Vermont reached 14,155 the percentage was reduced to 4.53 per cent.

Dr. Stalker reports that in Iowa about 14 per cent. of tuberculosis was found in 50 herds tested.

To secure a fair percentage on which to base estimates it is needful to take a census of the cattle with reference to herds and localities and then to test the proper proportion of small and large herds in different localities. In this way it would not be necessary to test all the cattle to know how many were tuberculous. Should only 1 per cent. of the dairy cattle of New Jersey prove to be tuberculous, the slaughter of but 2,000 animals would practically rid the State of this bovine disease. Of course the slaughter would be very extensive in some localities.

WHAT IS TUBERCULOSIS?

This disease is characterized by the growth of lumps, called tubercles, in various parts of the body.

Description of the Tubercles.—These are generally round in shape, but vary in size, some being as small as ordinary shot, others as large

as a plum, the average being like a grape. They lie either in the affected organ or upon its surface; usually several are clustered together, or they have sometimes grown into masses as large as a man's head. When many small tubercles are scattered over a considerable area, the lesions constitute "miliary tuberculosis."

Development of a Tubercle.—At the spot or "focus" where a tubercle is to develop, there is first a slight inflammation, the area of which gradually spreads as the tubercle grows. In the central part of the focus there is formed a collection of fibrous tissue. There is also a gathering of lymph cells that become enlarged and broken up. Then the interior of the tubercle becomes firmer and pale in color; sometimes lime-salts are deposited, so that it becomes brittle, but usually the center is composed of a yellow material which cuts like cheese and is called "caseous" matter. The surface consists of dense connective tissue which may form a covering or "cyst." In the encysted condition tubercles cease to grow, being in a resting or quiescent stage. Frequently, however, the center becomes soft, an abscess is thus formed which ultimately discharges its contents.

Location of Tubercles.—It is connective and lymphatic tissue that is involved in the growth of a tubercle. But these tissues are very widely distributed in the body, so that almost any part of the body may become the seat of tubercle, although there are, as we shall see, certain organs that are the most frequently diseased. Tubercles forming in different organs and localities have given rise to local symptoms that have received names as distinct diseases.

Varieties of Local Tuberculosis.—"Lupus" is tuberculosis of the skin. In cerebral and spinal *meningitis*, the tubercles grow on the membranes surrounding the brain and spinal cord. Brain tuberculosis also causes various forms of *insanity* and other *nervous disorders*. Tuberculosis of the joints causes swelling, stiffening and ultimate softening of the bone, thus differing from other forms of *arthritis*. Tuberculosis of the ovaries produces *sterility*; in the womb it causes chronic *abortion*; and some cases of "white flow" or *leucorrhœa* are due to tuberculosis of the womb or of the vagina.

In the udder the presence of tuberculosis has been taken for "garget," or *mammitis*, from which it differs in that it begins as small, localized, hard swellings, that persist, grow steadily, and are not hot to the touch. When the lymphatic glands of the neck and groin are affected, the disease is termed "*scrofula*." If the intestinal

glands are affected, there is either chronic *diarrhœa* or else "*irregularity*" of bowels with alternate constipation and looseness. Tuberculosis of the mesenteric glands constitutes *tabes*. Some forms of "liver complaint" are also to be placed to the account of this disease; frequently is this organ or its portal lymphatics invaded; and even if no tubercles are present in the liver, its substance is usually very friable and abnormal in tuberculous animals. The glands situated at the back of the throat in cattle, known as the post-pharyngeal, are frequently involved; but those of the chest, where the branches of the windpipe enter the lungs (bronchial glands) and those between the gullet and the back, particularly near the diaphragm and between the hindmost lobes of the lungs (mediastinal glands), are the most frequently affected of all. Sometimes one of these glands, normally not wider nor longer than one's little finger, increases hundreds of times in volume, becomes over a foot long and very thick, and weighs more than ten pounds. This must greatly limit the breathing capacity even if the lungs are sound. *Phthisis*, or "pulmonary consumption," is the name given when the lungs themselves are tuberculous. These organs are involved in three-fourth of the cases of tuberculosis, and rarely are they alone affected.

WHAT CAUSES TUBERCULOSIS.

Different Kinds of Tubercles Produced by Different Kinds of Parasites.—There are several kinds of parasites that cause tubercles to develop on both plants and animal organisms. Many of the warty growths on the bark or roots of plants are caused by parasitic fungi. The "galls" on leaves result from the presence of developing insect larvæ. The "lump-jaw" of cattle, or *actinomycosis* (which is Greek for ray-fungus disease), is a hard tubercle caused by a bacterial fungus. The pimples, sometimes found on the surface of the intestines of cattle, contain each a little worm. Carbuncles and various abscesses may ultimately be traced to the irritation of some parasite. Even dead objects, like nails, bullets, etc., imbedded in animal tissues become inclosed in cysts of connective tissue. These various growths superficially resemble the tubercles of tuberculosis, though an experienced man need not to err in diagnosing true tuberculosis.

Tubercle Germs.—That consumption was caused by parasites was suspected long before Koch, in 1881, discovered the germs of this dis-

case, by submitting the material in which tubercle germs were supposed to be, to the prolonged action of the strongest aniline dyes, such as fuchsin. By this means the germs present are usually successfully stained so as to render them visible when properly magnified. As most other germs receive the stain in a minute or two it is no wonder that the tubercle germs remained relatively so long undiscovered. To view the germs it is next necessary to wash the preparation with a 25 per cent. solution of nitric acid in water, or in acidulated alcohol, and to submit a thin layer to examination with a microscope magnifying at least 500 diameters. The germs will then appear as very small colored rods (or bacilli), irregularly bent, and about one hundred thousandth of an inch thick, while the length averages about ten times as much.

These germs are generally not demonstrable by this method, in caseous material. But long before the germ theory of disease was established it was known that such material, when inoculated into susceptible animals, produced tubercles in which the bacilli are easily found. It is presumed that in old tubercles the germs have broken into fragments, similar to the "spores" of other germs, that are stained with great difficulty.

Tubercle bacilli are harder to kill than most other disease germs. They pass through the processes of digestion unaffected. They are not killed until heated to 150° F. for a period of nearly an hour, 160° for about a quarter of an hour. In the case of large pieces of meat the center usually remains, during cooking, at a much lower temperature than the surface. However, a degree of heat too low to destroy the germs weakens their virulence.

The Germ Theory of Disease.—So many diseases have been shown to be produced each by a specific parasite of the sort known as bacteria or "microbes," that it is supposed the majority of diseases are of germinal origin. These bacteria grow rapidly and multiply by splitting in two, so that a single one will, under favorable conditions, give rise to millions in a short time. They throw off from their bodies various poisons or toxins, which produce the disturbance we know as the symptoms of disease. When the germs have had time to become numerous in the body they cause a rise of temperature known as a fever. In ordinary fevers the germs multiply so fast that the fever may develop in a day or two after infection, but in

consumption the "hectic" fever is often delayed for years. This is because tubercle germs multiply with great slowness.

Microbes are dependent upon certain conditions of heat, moisture, etc., for their development. It had been evident to all men before germs were dreamed of, that diseases depended for their development upon the concurrence of certain circumstances or conditions of climate, weather, drainage, etc. It has now been proved that no conditions, however favorable to the development of disease, can of themselves produce disease if germs be absent. Disease can develop only when two factors concur, viz., presence of germs and conditions favorable to their development. If we can change either factor we control the occurrence of disease. This discovery has greatly perfected sanitary science, for in the past we could only attempt the regulation of conditions, but now we strive even more zealously to annihilate the power of the other factor. We disinfect; we apply antiseptics and germicides.

Susceptibility and Immunity.—The condition of the body is so important in determining whether or not disease shall develop as almost to deserve consideration as a third factor, for, granted that germs are present and the external conditions are favorable to the development of disease, if several animals be equally exposed to infection, some will be attacked and others not. The former are said to be "susceptible," the latter "immune" towards the disease. These conditions may be analyzed as follows:

1. It is the function of the white cells of the blood (lymph cells or leucocytes) to swallow and digest germs when they enter the body. These guardians of health may be strong and numerous or weak and few; they may readily overcome one species of germ while they may be paralyzed by another. Tubercle germs do not as a rule multiply in the blood, but they multiply in the lymph cells, causing the latter to enlarge and to disintegrate.

2. The number and strength of the germs that enter at once or the frequency with which the infection is repeated, as related to the power of the body to resist invasion, is important. The rabbit, for instance, not so susceptible to tuberculosis as the guinea pig, will usually not become tuberculous if the germs that are inoculated have been heated to 140° F., or if they are fewer than 150 in number. Many a patient exposed to infection might have conquered had the ventilation been better, for in this way the number of germs present in the air

would have been reduced, or had sufficient light flooded the room inhabited. Sunlight soon weakens tubercle germs, but we are assured that they retain their virulence for months in dimly-lighted rooms. In these cases we see well the relation between internal and external conditions.

3. The amount of stress or strain under which the organism is laboring is a factor. Animals ordinarily immune can be made susceptible by exercising their muscles until they are overtired. Among other strains may be mentioned improper nutrition, overchilling, overheating, breathing air deficient in oxygen, lack of sleep, excessive nursing, forced milking, worry and grief.

4. In the case of several diseases (questionably so with tuberculosis), recovery from one attack confers immunity against subsequent attacks. If the blood of an immune animal be inoculated into a susceptible one, it will render the latter immune also. When a patient recovers from a disease, it is supposed to have been due to the fact that his tissues have manufactured an antidote to the bacterial poison, or a counter-poison called anti-toxine, which has a repressing or attenuating action upon the germs. By cultivating germs under artificial conditions they become so changed as to make a weakened poison. These "attenuated" germs when inoculated or vaccinated into an animal produce a mild form of disease, under the stimulus of which the body acquires immunity against stronger attacks.

The toxine of tuberculosis is called *tuberculin*, whose anti-toxine is "anti-tuberculin." In chronic cases of tuberculosis there is not enough tuberculin secreted or at least it is not secreted fast enough to cause a fever. But the presence of the germs has produced some effect on the tissues, rendering them sensitive to the sudden accession of a small but appreciable quantity of tuberculin, as is shown by the occurrence of the reaction fever that is produced in tuberculous animals subjected to the Koch test. If the injection be repeated on the same patient, the reaction is less in extent. It usually takes only three or four injections to make a tuberculous animal irresponsive to the Koch test. Some authorities have reported such cases to be cures, though it will take some time to prove this to be true. It is at least supposable from analogy with other fevers that the reaction produced by the Koch test may be accompanied by the manufacture of anti-tuberculin. There is great uncertainty surrounding these experiments, since repetition of tuberculin injection does not produce even a

so-called (though doubtful) cure in every case, and usually after a sufficient period of rest (a year, more or less), a reaction may again be provoked. On this head see the report of the Biologist, New Jersey Agricultural College Experiment Station, for 1895 and present report. Cattle, at least, seem to show slight, if any, evidence of possessing immunity against tuberculosis.

The Question of Heredity.—The fact that consumption frequently “runs in families” has lent a good deal of force to the belief in the presence of a real susceptibility and immunity, which, in whatever way acquired, could be handed down through several generations. When germs were discovered, the doctrine of heredity as regards diseases was made to include cases of “congenital infection,” that is, the unborn child was supposed to have received the germs of disease from the maternal (or paternal) body. Recent observations have shown that only a very small percentage of calves are born congenitally infected. Few calves are tuberculous, anyway, as compared with adult animals; but even of these, the majority have become tuberculous from drinking milk containing germs. There is plenty of proof to show that if infection after birth be obviated, the children of consumptive parents do not become tuberculous, and on the other hand, numerous very bad cases of consumption have occurred among men and animals whose ancestry showed no trace of this disease. If consumption runs in families, it is because the children of consumptive parents are especially exposed to infection.

DEGREES OF TUBERCULOSIS.

Paths by which the Germs Enter the Body.—Neglecting unusual methods of infection there are two main avenues by which germs are received, viz., by the digestive canal with the food, and by the lungs with the dust of the inbreathed air. The resulting tubercles will show by their situation and extent of development by which of the two paths the germs entered. In any case the germs lodge first upon the free internal membranes of these organs, then they are picked up by the wandering lymph cells, and are transferred into the nearest lymph glands. These glands when charged with germs fail to guard the receiving organs, which then become the seat of tubercle. In the case of the lungs of cattle, it is the dorsal part of the posterior lobes into which the main bronchi run most directly, that are most often

the seat of primary lung tuberculosis. Infection of the lymphatics of the throat or of the abdominal cavity is called "feeding tuberculosis," showing that the germs were received in the food rather than by breathing. Tuberculous calves are usually cases showing feeding tuberculosis.

Secondary Tuberculosis.—Primary tubercles are those produced by infection from without. When one of the primary tubercles advances to the stage in which it discharges, its contents on their way out of the body can set up tuberculosis, not only in places where primary tubercles are capable of forming, but also in other parts of the body. We are indebted to Dr. Theobald Smith for a lucid account of this subject. Enough must be given here to give the general reader a fair notion of how secondary tuberculosis develops, because it is in this stage that the patient becomes a source of danger to others as well as a source of re-infection and auto-infection to himself. In case the tubercle discharges in the lungs, the matter passes out into one or more of the following places, the windpipe, the chest cavity, the pulmonary veins, the thoracic lymphatics. From the windpipe the discharge is coughed up and either expectorated, to become a source of infection to all (including the patient) who breathe the air laden with this dust, or the discharge is swallowed. Some of the germs must stick to the mouth and lips, from which they will infect the throat glands. Those swallowed reach the abdominal lymphatics, and some escape with the feces, to become a source of danger to other animals, such as pigs. In the case of cattle the coughed-up mucus (sputum) is usually swallowed, but at times some enters the mouth and nasal cavities. Then the germs may be carried in the slime or "drool" that comes from the cow's muzzle.

If the discharge is into the chest cavity, miliary tuberculosis will be set up on the serous or pleural membranes of this cavity, the front side of the diaphragm and other thoracic organs. If the discharge passes into the bloodvessels the germs will be carried into every part of the body, such as the brain, joints, kidneys, udder, etc., thus setting up what is termed generalized tuberculosis, the worst sort of all. The germs may then enter the milk, the urine, the vaginal discharges, etc. Infected milk dripping to the barn-floor becomes a source of tuberculous dust. If a sound cow lies in the infected stall the germs will cling to the outside of her udder, to fall into the milk pail or to be received by her suckling calf. There is no end to the

possibilities of infection after an animal once begins to pass off germs. Large herds have become greatly infected from a single case of advanced tuberculosis. In case the discharging tubercle is one of "feeding tuberculosis," the germs may either pass out through the intestines or may produce miliary tuberculosis of the peritoneal membranes, and on the abdominal organs; or if they are carried into the thoracic duct they will infect the lungs by way of the general circulation. Injection of germs into the abdominal cavity frequently causes tuberculosis of the lungs, in experiments conducted upon animals.

MILK AS A SOURCE OF INFECTION.

The danger to human beings, especially infants, from bovine tuberculosis, lies in the chance of infection from cow's milk. There is probably slight, if any, danger in the use of milk from cows while they are in the primary stages of tuberculosis. The danger becomes real in the secondary stages. Then the udder usually becomes infected, though not always right away. Ernst found the udder free from tubercles in 14 per cent. of cases of tuberculosis advanced far enough to be diagnosed by veterinary inspection; nevertheless, in one-third of these animals (that is, tuberculous cows with sound udders) he found tubercle bacilli in the milk.

SYMPTOMS OF ADVANCED TUBERCULOSIS.

In the early stages of primary tuberculosis the health of the animal seems to be unaffected; frequently the patient shows an increased tendency to lay on fat. Unless the lesions are in the lungs, the veterinarian usually has great difficulty in diagnosing the disease. But the symptoms of secondary tuberculosis are very evident. No person should keep a cow alive which manifests any of the following symptoms; nevertheless it has frequently happened that such animals have been milked as long as they could stand up: Beware of the cow which, if well cared for, has a long-legged, pinched-chested appearance, with shoulder blades sticking out, back arched, and with a pale, emaciated look. The skin is dry and hidebound, the coat lacks sleekness, the milk is deficient in fat, decreasing greatly in yield. The faeces are dark, pungent and watery. Laxatives, when administered, act too readily. Beware of the cow with ill-shaped udder, containing hard lumps, or with swollen lymphatics. When pressure is

applied to the chest-wall the animal shrinks away from the hand. If the temperature in old animals frequently exceeds 103° F. at 5 P. M., it is cause for grave suspicion. On the other hand, in the morning the temperature is usually abnormally low. A cow extra stupid, or extra excitable, always bulling and subject to sterility or to abortion, is probably tuberculous in the brain or in the genital organs. A persistent cough is present, or if there be only occasional cough while standing still, this may be increased by exercising the animal or by pressure on the chest, or by giving drink.

If by veterinary inspection all cases of secondary tuberculosis could be removed, we might by this means succeed in suppressing bovine tuberculosis. At any rate such inspection should never be neglected. Both owner and inspector should be held legally responsible if cows evidently tuberculous are kept for milking purposes.

But ordinary physical inspection in diagnosing tuberculosis is not sufficiently reliable to give us hope that by its means alone we could keep down this disease, although with proper care we could greatly restrict its development. In the Koch tuberculin "test" we have a means of discovering not only all animals that are dangerous or liable soon to become dangerous, but also cases in early stages of the disease that may not become dangerous, at least for a long time. Unfortunately for the popularity of the "test" it fails to show to which of these two groups, the reacting animals belong. It seems a waste of effort and unnecessarily severe to condemn animals slightly affected, equally with dangerous cases. Yet who thinks that could we suppress tuberculosis in no other way, that this price is too great as compared with the benefits to be secured?

THE TUBERCULIN TEST.

Robert Koch announced in 1890 that if a glycerine extract of the toxins of tubercle germs, called by him tuberculin, were injected into tuberculous animals, a fever would be caused in from six to twelve hours after injection, which would last for a number of hours. He believed that repeated injection would cure tuberculosis, but it was soon found that in advanced cases in human beings the disease was really increased by such injection.

Is the Test Injurious?—The reaction fever is absent if no tuberculosis is present, but some effect is produced even then, for there is a

decrease in the milk yield, which is greatest in about four days after the application of the test, and then gradually the normal yield is restored. Dr. Law thinks that large doses do cause a rise of temperature even in healthy cows. The amount ordinarily used is twenty-five drops of diluted tuberculin for each thousand pounds of weight of the animal. This quantity does not affect the temperature of sound animals.

Tuberculin which is properly made has been subjected to heating so that the germs in the "lymph" have been deprived of their vitality. The uniform experience of those who have made thousands of tests is that no injurious effects have been noticed even after repeated injection of sound or of slightly-tuberculous animals; indeed, the latter appear to be benefited. But as regards the effect upon some thoroughly-tuberculous animals, opinion is divided.

Procedure in Making the Test.—To diagnose the presence of tuberculosis by means of this test, it is necessary to observe whether or not the temperature of each animal is affected by the tuberculin it receives. This constitutes the only real difficulty, because the temperatures of different animals is different at the same time; young animals usually are warmer than older ones; the temperature of the barn affects different animals unequally; the drinking of water lowers the temperature for a period as long as an hour afterwards; the presence of other diseases, the approach of calving, and the presence of rut (œstrum) usually raise the temperature; but that which causes most difficulty is the fact that the temperature of each animal is constantly fluctuating between a higher and a lower degree—different with different animals, and different on successive days. The average of observations taken every half hour or so shows that generally the temperature is lowest in the morning and at midday, and highest about 9 A. M. and 5 P. M. But there are exceptions.

The best that can be done is to observe the temperature of each animal at intervals of not less than two hours, during the day, to ascertain the normal fluctuations of temperature. About bedtime, the proper quantity of tuberculin is to be injected under the skin of the shoulder as the most convenient place, after rubbing the spot well with a 4 per cent. solution of creolin, as an antiseptic precaution.

Then during the following day the temperature is to be observed as it was during the preceding day. The reaction will occur by 9 A. M. or earlier, or it may be delayed until the afternoon. The higher

the reaction the sooner it occurs and the longer it lasts. In a typical case the temperature will begin rising as early as 6 A. M. and may reach 107° F. by noon. In case the temperature rises only slightly, say fails to reach 103 or 103.5°, it will usually be impossible to be sure that such rise is due to tuberculin.

Sources of Failure and Limitations of the Test.—1. Cows with advanced tuberculosis fail to react. The tuberculin naturally present in such animals has already caused reaction (the hectic fever) so repeatedly that no great reaction is possible. As such cases do not require tuberculin injection to discover their diseased condition, this source of failure does not count against the value of the test.

2. Cases of slight reaction are not distinguishable from cases in which the temperature of a sound animal is a little higher one day from what it was the day before. To destroy the former it is necessary to arrange them in the order of their certainty, and beginning with the most certain ones, to slaughter them *seriatim* until the carcasses cease to show the lesion of the disease. Or these cases may be re-injected six or more months later. If they are sound to physical inspection, it may be considered as perfectly safe to let them wait.

3. Cases that have been previously injected and have given reaction, give a less certain reaction at a later test. Experiments show that the power to react is regained after six or more months of rest. Different cows differ in these respects. Prof. Bang found that 7 to 20 per cent. of the cows lost the power to react on the second injection, others require three or four repetitions before losing sensibility. Some observers report that a reaction can be secured if a sufficiently large dose be injected.

4. Cases of recent infection and some cases of latent disease fail to give a reaction. But these can be secured by testing the entire herd again later. Prof. Bang found that on a second injection of some herds he secured 10 per cent. additional reactions, but the third injection added only one animal, so that if a herd be tested two or three times, it may be practically freed from cases of this disease, within two years.

5. Very rarely has it been found that animals with diseases other than tuberculosis respond to the injection of tuberculin. Prof. Bang found two cases of reaction in which the post mortem failed to show presence of tuberculosis. Evidently these cases are too few to be counted against the test. After including all sources of errors, the

tuberculin test applied by experienced persons shows at least 90 per cent. of efficiency. *By its aid we are able to eradicate bovine tuberculosis.*

This desirable result has been aimed at by the dairymen of Denmark. Such success has been attained that they have great hopes of succeeding. It will be remembered that in that country tuberculosis is much more prevalent than it is here.

THE DANISH METHOD OF ERADICATION OF TUBERCULOSIS.

This method, based upon extensive experiments by Prof. Bang, is voluntarily adopted without government compulsion, the self-interest of the farmers being sufficient stimulus. In this work there are ten steps to be taken.

1. The herd is inspected by a veterinarian, and all evidently tuberculous animals are at once removed and carefully slaughtered.

2. The remainder of the herd is tested with tuberculin, given free by the government, provided the farmer agrees to follow, rigidly, the remaining steps of the process.

3. All cows that react and all adult animals of little value, that have shown evident reaction, are carefully slaughtered under inspection. If the beef seems to be prime, the carcass is marked as having been slaughtered as tuberculous beef. Those who buy it secure it at half price, and, of course, if it is thoroughly cooked it is as safe for food as any beef.

4. The remaining reacting animals are carefully separated from the non-reacting animals, either in a separate building or in the opposite end of the same building, a complete partition being at once constructed separating the two divisions. The partition is made of matched boards, and is papered. There is no opening left by which air can pass from one compartment to the other. The drainage is so arranged that nothing can soak beneath this wall. If possible, a separate set of attendants care for each division. Where but one man milks and cares for all the cows, he serves the sound division first, then he changes overshoes and outer garments for special clothing used only when with the reacting division.

5. Both compartments are cleaned and disinfected as follows: All manure and litter is removed and burned or treated with germicides. The floor, walls and ceiling are wiped with a wet rag, frequently

rinsed in disinfectant solution. Then the entire interior is sprayed with one of the following solutions, either *A*, *B*, or *C*:

A. One pound chloride lime in four gallons water.

B. One-half gallon crude sulphuric acid slowly mixed with one-half gallon crude carbolic acid slowly diluted with twenty gallons water.

C. In a wooden tub put eight gallons warm water, add one ounce of corrosive sublimate, let stand a day to thoroughly dissolve. This is a powerful poison. It must not be used in contact with metal instruments, but can be applied with a brush. All parts that can be reached by the tongues of the animals must be rinsed off with pure water after this disinfectant has been applied. When walls and ceiling are dry they are whitewashed. (Corrosive sublimate can be added to the whitewash.)

6. All the milk produced by the reacting animals should be heated to 185° F. before use. No milk should be given to the calves without this pasteurization process unless its purity is undoubted.

7. All calves dropped by reacting cows should be put with the non-reacting division before they get a chance to suckle their mothers. For the first day they should receive their mothers' colostrum (milk) after heating it to 149° F.

8. The sound herd should be tested a second time within a year and all reacting animals removed to the other division.

9. In buying a new cow she should be tested at once, so as to know in which division to place her.

10. The reacting herd should be inspected by physical examination at least once a year, to discover if any cases have become so advanced in tuberculosis as to show physical signs of the disease, when they should be sent to the slaughter-house as tuberculous beef.

By this method the unsound herd will, in time, be wiped out, but not before it has replenished the sound herd to its original dimensions. Of course, if only a few animals are found tuberculous, it will not pay to go to the expense of keeping a separate herd. But when dealing with a considerable number of prize animals, whose qualities are worth propagating, it will undoubtedly pay to follow the Danish method. It is simply a question of which is the cheaper course in the end, to try to raise a sound herd from an unsound one by observing rigid rules, or to get rid of all the tuberculous animals at once. Each farmer must determine this for himself.

At any rate, to keep one's herd free from tuberculosis, after it is once purified, or even to thoroughly purify a herd, requires just that careful attention which is necessary in applying the Danish method. This method is in itself a most remarkable educator, and the principles that underlie it are part and parcel of the general biological principles that interest all intelligent breeders. *It is certain that if our people are left in ignorance and without this practical education, that in spite of a wholesale slaughter of tuberculous animals, it would be but a few years before the herds of the country would again have become as infected as they are now.*

WHAT TO DO TO KEEP TUBERCULOSIS FROM DEVELOPING IN OURSELVES.

If we have no guaranty that the milk we are using or are giving to our children comes from a purified herd, it should be placed over the fire and heated to 170° or 180° F. In the absence of a thermometer, it is only needful to see that it stands on the fire long enough to form a thin skin over its surface, and that little bubbles of steam gather beneath. This heating, if stopped at this point, does not produce "boiled" milk. Boiled milk, if not scorched, is greatly relished by many people. While it is true that raw milk (like raw eggs, meat, oysters, etc.) is more easily digested than that cooked, this is not sufficient reason for limiting us to its use in the raw state. Cooking will also destroy other bacteria, which are always present to a greater or less extent, though these are usually harmless. Milk, even when cooked, is the most perfect of foods and the safest.

Consumptives will, of course, need but to know that their sputa contain germs, to cause them to disinfect or burn their expectorations. They will cease to live in darkened rooms. They will insist on having the carpets taken up and never more have their rooms swept, but will always have the dust wiped or washed off.

People who wish to keep from getting consumption will never expose themselves in crowded public places where the ventilation is inadequate. They will dress as one does when about to take a buggy ride, and then will be able to sit in any sort of weather in any place, with all windows open. This and this alone the writer believes to be perfect ventilation. Our public halls and railway coaches in winter

time are at present efficient death-promoting agencies. It is also important to screen all food that is not to be cooked, from flies, as these insects may carry all sorts of germs.

THE CONTAGIOUSNESS OF TUBERCULOSIS.

Any disease produced by germs is contagious, infectious or "catching." In such disease there are special ways in which the germs are transferred from a patient to a healthy person. We have learned enough about consumption to know what constitutes exposure to this disease. As no one knows at any one time to what extent he is exposed, and as this disease takes a long time to develop it is quite difficult to connect any particular case with a particular act of indiscretion. Under the circumstances, people in general have no very positive belief that consumption is really a contagious disease, though this has been definitely proven by scientific experiments. Many coincidences of exposure to the germs of consumption with development of this disease, which would be of uncertain value as proof of contagiousness if taken by themselves, are very suggestive when viewed in the light of the knowledge that this disease is a germ disease. In this connection one bit of positive evidence outweighs hundreds of merely negative instances. As the care which people will exercise in dealing with this disease will largely depend on the firmness of their belief in its contagiousness or its infectiousness, efforts to establish this belief are of value. Hence we shall proceed to refer to a few instances recorded by different writers.

In 1860, Chauveau fed "scrofulous" products to cattle and produced "scrofulous" (consumptive) disease. Bollinger fed the milk of tuberculous cows to guinea pigs and tuberculosis developed in them. One way of testing milk to see if tubercle germs are present, is to inject a quantity into the abdominal cavity of guinea pigs. Even when the germs are present in so few numbers as to be incapable of demonstration by microscopic examination, the inoculated animals become tuberculous. Ernst inoculated milk of tuberculous cattle with sound udders into guinea pigs, and half of the inoculated animals became tuberculous. Milk from the same cows fed to a number of swine, caused half of them to become tuberculous. Drs. Stalker and Niles separated three calves from their mothers at birth, and gave them the mixed milk from several tuberculous cows, but always heated the

milk that one calf received. This animal did not become diseased, the other two became tuberculous. Dr. Schroeder found that one sample out of nineteen, secured from the general milk-supply of Washington, D. C., produced tuberculosis when inoculated into a guinea pig. Dr. Ernst found three out of thirty-six samples of Boston milk to be similarly infectious. Prof. Bang placed two healthy bulls with the reacting division in his experimental herd, and within a year they too reacted when injected with tuberculin. Cornet inoculated guineas with dust from rooms occupied by consumptives, and compelled other guineas to breathe such dust, and produced tuberculosis in the experimental animals. It is a general observation that when cows occupy the same stalls and do not intermingle, that tuberculosis spreads from the diseased animal to its nearest neighbors first; while in case the stalls are used indiscriminately, the entire herd is irregularly affected.

Many infants die of bowel troubles that suggest "feeding tuberculosis." It has in a number of cases been found that the milk received as the sole food by such infants was received either from a consumptive nurse, or mother, or tuberculous cow. In Dr. Ernst's extensive correspondence with physicians on this subject, he found 8 cases reported in which infection was conveyed from mother to child, 11 cases of transfer from cow to infant, and 16 cases where this mode of infection was suspected. Veterinarians are better situated to observe such cases than ordinary physicians. Dr. Stalker reports that five young people in one family died of consumption during two years, and their ancestors had been free from such disease. An investigation of the herd belonging to the family showed that it contained 17 tuberculous cows, and others had previously died of tuberculosis.

Cases are on record of the children of non-tuberculous mothers, both human and bovine, being nursed by foster-mothers who were tuberculous, and who had lost their own babes from this disease. The previously-healthy children, under these circumstances, begin at once to pine away and finally die from tuberculosis. Prof. Bang reports that tuberculous horses are rare except in Denmark, where the unique practice prevails of feeding these animals cow's milk. Where pigs are fed milk from tuberculous herds, they show a large amount of tuberculosis. A case was reported to the Paris Academy of Medicine of an outbreak of consumption in a girls' boarding school; five girls died from intestinal tuberculosis, and this led the physician to suspect

the food. He found that this school had been supplied with milk from a cow with a tuberculous udder.

Other instances will be found reported by the different authors named below. The list includes mainly American publications on this subject. To these various publications we are indebted for the facts rehearsed in the previous pages. This list is in no sense intended to be complete, even of the Experiment Station reports and bulletins.

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REPORT OF THE BOTANIST.

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REPORT OF THE BOTANIST.

The work in the Botanical Department for the year ending November 30th, 1896, has been mainly with field experiments at the College Farm and elsewhere in the State, supplemented with investigations in the laboratory.

The experiment acre of the past two years has been extended so that nearly two acres are included, and is now known as the Experiment Area.

The chief lines of work have been with fungicides upon the various truck crops, namely, turnips, potatoes, beans, tomatoes, peppers, egg-plants, cucumbers, celery, beets, peas, sweet potatoes and a few kinds of ornamental plants.

Experiments with sweet potatoes have been made upon four separate fields in the State, all of which again point to sulphur as an efficient remedy for the soil rot.

A study of the peach gall has been a leading feature of the work in the greenhouse.

The herbarium has been enlarged by a few hundred specimens, and the index of the host plants now includes all of the more than 20,000 specimens.

Some work has been done with weeds and a new device for detecting foul stuff in commercial seeds constructed.

Since the last report was issued, Bulletin No. 115, "Irrigation of Garden Crops," has been published.

Mr. James A. Kelsey, as field assistant, has had charge of the details of the experiments at the College Farm, and has aided greatly in the preparation of this Report.

THE EXPERIMENT AREA.

In 1894, five crops were experimented upon, namely, turnips, cabbages, tomatoes, potatoes and beans. In 1895, this list was modified somewhat by discarding cabbages, because turnips answered all the purposes for tests of fungicides for the club-root common to these two crops, and in adding to the list the following crops, namely, peppers, egg-plants, cucumbers and celery. In land adjoining to the acre privileges were granted for experiments upon beets and carrots, and therefore quite a full list of the truck crops of the State was represented. Upon the three succeeding pages are diagrams (Figures 1, 2 and 3) showing the plans of the Experiment Area for the years 1894, 1895 and 1896.

In 1894, each of the five crops occupied the same amount of space; that is, each had a series divided into four plots, as shown in Figure 1*. The crops in 1895 were disposed as shown in Figure 2. It will be seen that the turnips were upon the old ground, the potatoes upon the series bearing cabbages last year; tomatoes occupied two of the old plots, while the other two were devoted to peppers. Upon the potato ground of 1894 (Plots I. and II.) were beans for the first crop, followed by celery, while the two other (lower) plots were given to egg-plants. The two upper plots of Series V. were again planted to beans, and upon the remaining two was grown a crop of cucumbers. To the left hand of the experiment acre and adjoining it was the beet-field, and to the right the area occupied by carrots.

The crops the present season (1896) were arranged as shown in Figure 3. Turnips remained upon the old ground where they have been for three years. Potatoes followed potatoes in Series II. In Series III. peppers followed peppers upon Plot I., while Plot II. was in potatoes (Rural No. 2); tomatoes followed tomatoes as a third crop upon Plot III., and beans were introduced for the first time upon Plot IV. In Series IV. turnips were introduced upon Plot I. after potatoes, beans and celery of former years; potatoes (Early Rose)

*The series are separated from each other by four-foot paths, and the plots in each series by two-foot spaces. Each plot is 33 x 66 feet, and is divided crosswise into six belts, each 11 x 33 feet. Each plot is one-twentieth and each belt one one-hundred and twentieth of an acre. This arrangement of the plots is given in detail in the report for 1894, page 278.

Series V.

Series IV.

Series III.

Series II.

Series I.

Beans.

Potatoes.

Tomatoes.

Cabbages.

Turnips.

Plot I.

Plot II.

Plot III.

Plot IV.

Fig. 1.

The Plan of the Experiment Acre for 1894.

	Series I.	Series II.	Series III.	Series IV.	Series V.
	Turnips.	Potatoes.	Peppers (Plots I. and II.)	Beans and Celery (Plots I. and II.)	Beans (Plots I. and II.)
Plot I.					
Plot II.					
Plot III.					
Plot IV.					
			Tomatoes (Plots III. and IV.)	Egg-plants (Plots III. and IV.)	Cucumbers (Plots III. and IV.)

Fig. 2.

The Plan of the Experiment Acre for 1895.

	Series I.	Series II.	Series III.	Series IV.	Series V.
Plot I.	Turnips.	Potatoes. Turnips and Beets.	Peppers, I.; Potatoes, II.	Turnips, I.; Potatoes, II.	Beans, I.; Potatoes, II.
Plot II.	Mustards.				
Plot III.	Beets.				
Plot IV.	Potatoes.				
					Tomatoes, III.; Beans, IV. Egg-plants, III.; Cucumbers, IV. Cucumbers, III.; Peas, IV.

Fig. 3.

The Plan of the Experiment Area for 1894.

occupied Plot II.; egg-plants succeeded egg-plants upon Plot III., and cucumbers were introduced for the first time upon Plot IV. In Series V., Plot I. had beans (Golden Wax) as its fifth successive crop; Plot II., potatoes (American Giants) followed two years in beans; cucumbers for the second year were upon Plot III., and upon Plot IV. peas were introduced for the first time upon the Experiment Area.

To the right of Series V., another series (VI.) was laid out and planted to potatoes (Early Rose), with celery as a second crop upon Plot IV. Still farther to the right is the space devoted to experiments with ornamental plants, and between this and the roadway nine experimental grass plots placed side by side form a border to the trial grounds.

Upon the left of Series I., another has been added (Series O) that this year was sown to beets for the third season. Beyond this is a narrow strip of land for various purposes, and the area ends in a border of grass plots similar to those upon the opposite side of the experiment grounds.

EXPERIMENTS WITH TURNIPS.

The purpose of the experiments conducted since 1894 in connection with turnips has been to determine a preventive of the destructive disease commonly known as club-root, caused by the fungus *Plasmodiophora Brassicae* Wor. The malady is also destructive to several other cultivated plants, closely related to and included with it in the same group of plants—the mustard family.

Probably none of the members of this family are more susceptible to the disease in question than the turnip.*

Before considering the experiments of 1896, it may be well to note briefly those of the two preceding seasons, a plan of which is herewith appended.

*For a description of the disease under consideration, the reader is referred to Bulletin No. 98, "Club-Root of Cabbages and Its Allies." In the report for 1894, pages 278-289, and that for 1895, pages 250-276, will be found an account of the experiments conducted with turnips during the past two seasons.

	Belt 1.	2.	3.	4.	5.	6.
Plot I.	1894. Lime. 300 bushels.	1895. 2d crop sprayed with Bordeaux.	1894. Lime. 150 bushels.	1895. 2d crop Irrigated.	1894. Lime. 75 bushels.	1894. Corrosive sublimate, 5,280 gallons.
Plot II.	1894. Gas-lime. 150 bushels.	1895. Corrosive sublimate, 83¼ pounds.	1894. Gas lime, 75 bushels.	Nothing.	1894. Gas-lime 37½ bushels.	1894. Bordeaux. 5,280 gallons. 1895. Corrosive sublimate, 16½ pounds.
Plot III.	1894. Kainit, 1,920 pounds.	1895. Copper sulphate, 1,200 pounds.	1894. Kainit, 960 pounds.	1895. 2d crop Irrigated.	1894. Kainit, 480 pounds.	1894. Cupram, 5,280 gallons. 1895. Copper sulphate, 600 pounds.
Plot IV.	1894. Ashes. 300 bushels.	1894 (Nov.) Lime, 600 bushels.	1894. Ashes, 150 bushels. 1895 (July). Salt, 60 pounds.	1894 (Nov.) Lime, 800 bushels.	1894. Ashes, 75 bushels. 1895 (July). Salt, 300 pounds.	1895, 1st crop sprayed with Bordeaux.

Fig. 4.

Plan of Turnip Experiments for 1894 and 1895.

The results obtained after growing four successive crops in soil so treated are summarized from the report of 1895 as follows :

Kainit, applied in the three following amounts, namely, 1,920, 960, and 480 pounds per acre, gave no favorable results as a preventive of club-root, and proved decidedly harmful to the turnips.

Ordinary unleached wood-ashes, when applied in the following amounts, namely, 300, 150, and 75 bushels per acre, respectively, failed to diminish the clubbing of turnips. The ashes act as a fertilizer and increase the size of the roots, but they are not recommended as a remedy for club-root.

Gas-lime, at the rate of 150, 75, and 37½ bushels per acre, respectively, gave no good results with clubbing of turnips. Besides this, gas-lime interfered with the growth of the crop.

Bordeaux mixture, applied in 1894 at the rate of 5,280 gallons per

acre, had no effect upon the club-root fungus, and destroyed more than half the turnips.

Cupram was also applied to a single belt in 1894, and gave no encouraging results.

Sulphate of copper (bluestone), when applied as a powder in early spring at the rate of 1,200 pounds per acre, proved injurious to the crop and did not diminish the club-root, but where the amount was 600 pounds per acre, the stand was good and the clubbing somewhat reduced in the second crop.

Corrosive sublimate was used in both the liquid and powdered form. When applied in powder at the rate of $33\frac{1}{2}$ pounds per acre, no favorable results were obtained, but with half that amount the crop was an average one in size, and the clubbing much below that of the check belt.

The results that have been obtained with air-slaked lime during the past two years, both in the spring and fall applications, justify its being recommended as a remedy for club-root in turnips and cabbages. The experiments indicate that not more than 150, nor less than 75 bushels per acre, should be used upon badly-infested soil, and the application is more valuable when made in the fall, and the lime left upon the surface during the winter.

TURNIP EXPERIMENTS FOR 1896.

The following diagram (Figure 5) indicates the plan of the experiments for the two turnip crops grown upon Series I. in 1896. The scheme necessarily embraces the soil applications of the present season and those of the two preceding years. Everything is in terms of per acre, and applied in the spring, unless otherwise indicated. The year is followed by whatever is added during that time, and no mention is made of the year when there was nothing applied :

	Belt 1.	2.	3.	4.	5.	6.
Plot I.	1894. Lime, 300 bushels.	1896. Sulphur, 300 pounds.	1894. Lime, 150 bushels.	Nothing. 1896. 2d crop Irrigated.	1894. Lime, 75 bushels. 1896. Irrigated.	1894. Corrosive sublimate, 5,280 gallons. 1896 (Nov.) Blighted tops.
Plot II.	1894. Gas-lime, 150 bushels.	1896. Corrosive sublimate, 32¾ pounds.	1894. Gas-lime, 75 bushels.	Nothing.	1894. Gas-lime, 33¾ bushels. 1896. Irrigated.	1894. Bordeaux, 5,280 gallons. 1896. Corrosive sublimate, 16½ pounds.
Plot III.	1894. Kainit, 1,920 pounds. 1896. Sulphur, 600 pounds.	1896. Copper Sulphate, 1,200 pounds.	1894. Kainit, 960 pounds.	Nothing. 1896. 2d crop Irrigated.	1894. Kainit, 480 pounds. 1896. 1st crop Irrigated. Carbonate of lime (June), 60 bushels.	1894. Cupram, 5,280 gallons. 1896. Copper sulphate, 600 pounds. Roots (Nov.)
Plot IV.	1894. Ashes, 300 bushels. 1896. Sulphur, 1,200 pounds.	1894 (Nov.) Lime, 600 bushels.	1894. Ashes, 150 bushels. 1896 (July). Salt, 600 pounds.	1894 (Nov.) Lime, 300 bushels.	1894. Ashes, 75 bushels. 1896 (July). Salt, 300 pounds. 1896, 1st crop Irrigated. Sal soda (June), 60 bushels.	Nothing.

Fig. 5.

Plan of Turnip Experiments for 1896.

As indicated in the above diagram, the plan of the experiments of 1895 varied somewhat from those of the first year, and additional changes have been made the present season. Since 1894, the second belts of each plot, at first used as a check, have each been converted into experiment belts by the addition of different chemicals to their soils, the check of Plot II. receiving an application of corrosive sublimate, that of III., powdered copper sulphate, and IV., lime.

Gas-lime, kainit, and wood-ashes had all proved worthless as preventives of club-root, and the half and quarter-amount applications, at least, had presumably lost most of their characteristic properties by the end of two years. These substances, therefore, were not likely to alter the effect of others that might be added to the same belts, and had probably ceased to have any influence upon the plants grown there.

The belts to which half and quarter-amounts of wood-ashes had been applied in 1894 were treated with common salt in 1895. Two of the cultural belts also received new treatment in 1895, that of Plot II., with Bordeaux in 1894, received half as much corrosive sublimate as was applied at the same time to the first check belt of the same plot. In like manner the cultural belt of Plot III. received a half-strength application of powdered copper sulphate. The tops produced by the second crop in 1895 were spread upon the soil of the cultural belt of Plot I., while the roots were applied to that of Plot III.

In April of the present year, sulphur was applied to the soil of three belts in varying amounts; to the first check belt of Plot I., at the rate of 300 pounds per acre, and the full-strength kainit belt of 1894 received twice as much—600 pounds per acre—while to the full-strength ashes belt of 1894, 1,200 pounds per acre was applied. The half-amount gas-lime belt was reserved for testing the susceptibility to club-root of various members of the mustard family, wild and cultivated. Beet and potato experiments were introduced upon the half-amount kainit and ashes belts of Plots III. and IV.

None of the belts were sprayed, and the foliage of the first crop was infested but little by fungi. The bacterial blight began to be manifest at about the time the crop was harvested, and all the belts seemed to be infested in about the same degree. By June 1st, or about five weeks after the turnips were sown, the presence of the root disease was evident in a majority of the belts. In certain ones all the plants were so severely infested that but little growth had been made above ground after the third week. Others had developed as much foliage as the uninfested plants, but that they were clubbed was recognized by the more or less wilted appearance of their leaves, which were of a much deeper shade of green than is usually assumed by healthy turnip plants.

The cultural belt of Plot I., treated with a dressing of turnip leaves in 1895, and that of Plot III., treated in like manner with turnip roots, were conspicuous for their greatly increased foliage.

Sulphur applied in 1896 nowhere gave evidence of having diminished the degree of clubbing, and none of the substances applied previous to 1896, with the exception of air-slaked lime, appeared to have been of any practical value as club-root preventives.

The first crop was harvested June 18th, and the turnips were badly scabbed, so much so that any attempts to separate and weigh those free from the scab was regarded as a waste of time. Upon the new land (Plot I., Series IV.) the scab was much less than upon the old land.

A large percentage of the roots when cut open showed a discoloration or a watery appearance just below the crown, and some were hollow in the center. All such turnips, when left upon the ground for a few days, turned dark, became slimy, and gave off a very offensive odor. Everything points to bacteria as the cause of this rapid decay. A bushel or so taken to the laboratory for study quickly spoiled, the ordinary soft-rot fungus *Rhizopus nigricans* Ehr. taking an active part in the destruction.

The results of the harvest of the first crop are given in terms of sound and clubbed roots in the accompanying table (Figure 6):

	Belt 1.	2.	3.	4.	5.	6.	
Plot I.	86 pounds. 0	13½ 84	85 1	25 60	76 ¾	18 48	Sound. Clubbed.
Plot II.	92 89	5 76	In Crucifers.	1 102	22 97	1 84	Sound. Clubbed.
Plot III.	0 68	0 52½	In Beets.	¾ 89	1¾ 88	1 84	Sound. Clubbed.
Plot IV.	18 110	95 48	In Potatoes.	72 56	7 60	1 79	Sound. Clubbed..

Fig. 6.

Results in Pounds of First Turnip Crop for 1896.

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The percentage of clubbed roots in each belt is herewith given (Figure 7):

	Belt 1.	2.	3.	4.	5.	6.
Plot I.	0	98.41	1.16	70.58	.65	77.41
Plot II.	29.77	98.75	In Crucifers.	99.02	81.51	98.82
Plot III.	100	100	In Beets.	99.45	98.82	98.82
Plot IV.	89.48	84.50	In Potatoes.	48.75	89.55	98.75

Fig. 7.

Results in Percentages of First Turnip Crop for 1896.

A comparison of the first crop of 1896 with that of the average of the four preceding crops shows, for the four check belts, a decided increase in the percentage of clubbing, as indicated in the following table:

	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Average of first four crops...	21.4	87.48	87.36	82.94
First crop, 1896.....	70.58	99.02	99.45	98.75

In the limed belts there is seen to be a marked falling off in the percentage of clubbing from that of the average of the four preceding crops, as the following table shows:

	Per Cent.	Per Cent.	Per Cent.
Average of first four crops.....	3.48	10.32	3.20
First crop, 1896.....	0	1.16	.65

The first crops produced upon the limed belts in 1895 and 1896 were both practically free from clubbing. There were 2.77 per cent. of clubbed roots in the first crop of 1895 in the full-amount belt and none in 1896, although the yield was more than double that of the corresponding crop of the preceding year.

There was an increase of clubbing in the half-amount belt, and a decrease in the quarter-amount belt, but the difference was less than one per cent. in either case. The percentage of clubbed roots in the second crop produced in the limed belts in 1895 was greater than the first in 1896 by 14.84 per cent. in the half-amount belt, and 6.36 per

cent. in the quarter-amount belt. In neither the second crop of 1895 nor the first of 1896 was there clubbing in the full-amount belt.

In the two check belts of Plot IV., treated in November, 1894, with lime at the rate of 600 and 300 bushels per acre, respectively, the percentage of clubbed roots was much lower than in the surrounding belts. The clubbing was somewhat less than in the first crop of 1895, but considerably greater than in the second of 1895. Compared with the average of the two preceding crops, the percentage of clubbed roots in the first crop of 1896 upon the full-amount belt will be seen to be almost the same, but in the half-amount belt it is considerably increased.

	Per Cent.	Per Cent.
Average of the two preceding crops.....	33.68	30.49
First crop in 1896.....	34.50	43.75

A comparison of the percentage of clubbing in the gas-lime belts for the first four crops and for the first crop of 1896 is given below :

	Per Cent.	Per Cent.	Per Cent.
Average of first four crops.....	49.74	30.57	60.87
First crop in 1896.....	29.77	.....	81.51

There is seen to have been a noticeable decrease in the percentage of clubbing in the full-amount belt and a corresponding increase in the quarter-amount belt. In the half-amount belt, as previously stated, no turnips were grown the present season.

In Plot III., the first kainit belt had been treated with sulphur, while the second was devoted to beets, so that only the quarter-amount belt remained in condition to have its first crop for 1896 compared with those preceding it upon the same area.

The percentage of clubbing in the quarter-amount belt was considerably higher than that of the average of the four preceding crops, as the following table shows :

	Per Cent.
Average of first four crops.....	83.39
First crop in 1896.....	98.32

The first ashes belt of Plot IV. was treated with sulphur, and potatoes were grown upon the second. The quarter-amount belt, to which salt at the rate of 300 pounds per acre had been applied in 1895, showed an increase in the percentage of clubbed roots, as indicated below :

	Per Cent.
Average of first four crops.....	68.81
First crop in 1896.....	89.55

Corrosive sublimate was applied in the spring of 1895 to belts 2 and 6 of Plot II. at the rates of 33½ pounds and 16½ pounds per acre respectively, and gave no indication the present season of having had any effect upon the root disease, as the following table shows:

	Per Cent.	Per Cent.
Average clubbing of first two crops.....	76.37	37.67
First crop in 1896.....	93.75	98.82

In belt 6 of Plot I., there had been, previous to 1896, very little clubbing—11.76 per cent. being the highest. Corrosive sublimate in liquid form of standard strength (1 to 1,000) had been added to this belt in 1894, and it would seem, therefore, to have been of value as a club-root fungicide. In the first crop of the present season, however, the percentage of clubbing had increased to 77.41 per cent., indicating that if corrosive sublimate prevented clubbing heretofore, a second application was necessary, since the first had evidently parted with its fungicidal properties. It is not unlikely that the belt in question was freer from the germs of the root disease at the beginning than were surrounding belts, and that the solution applied was therefore credited with greater value than it possessed. As already stated, corrosive sublimate applied in solid form proved worthless as a preventive of club-root.

Like results were obtained the present season in belts 2 and 6 of Plot III., treated in the spring of 1895 with copper sulphate at the rates of 1,200 and 600 pounds per acre, respectively:

	Per Cent.	Per Cent.
Average of first two crops.....	89.84	70.22
First crop in 1896.....	100.00	98.82

Sulphur was applied in April, 1896, to belt 2 of Plot I., and seemed to have no effect upon the root disease. The percentage of increase in clubbed roots in the belt so treated was even greater than in the check belt of the same plot. Like negative results were obtained in the first belts of Plots III. and IV., treated with sulphur at the rate of 600 and 1,200 pounds per acre, respectively.

A second crop of turnips was sown July 1st of the same variety as that of the first, namely, the Early Snowball. No changes were introduced except in Plots III. and IV. To belt 5 of the former calcium carbonate was added at the rate of 3,000 pounds per acre, while sodium carbonate (sal soda) was applied at the same rate to belt 5 of Plot IV.

At the end of two months (August 31st) the crop, a very small one, was harvested, and the results obtained are presented in the following tables (Figures 8 and 9):

	Belt 1.	2	3.	4.	5.	6.	
Plot I.	4¾ pounds. 0	0 7½	1¼ ½	0 5½	¾ 0	4¼ 8½	Sound. Clubbed.
Plot II.	¾ ¾	0 6½	In Crucifers.	0 12½	½ ¾	¾ 8½	Sound. Clubbed.
Plot III.	0 8½	0 7½	In Beets.	0 8½	0 8½	0 12½	Sound. Clubbed.
Plot IV.	0 12¼	4 ½	In Potatoes	5¼ ¾	0 7½	0 4	Sound. Clubbed.

Fig. 8.

Results in Pounds of Second Turnip Crop for 1896.

As might be expected of turnips grown at so unfavorable a season, the yield was extremely light, and there were no roots of a marketable size, even among the unclubbed. But the extreme heat of mid-summer, although detrimental to the normal development of turnips, seemed to have an opposite effect upon the parasite preying upon their roots. When harvested, the turnips were found to be distorted to a much greater degree than any grown upon the same land since the experiment began.

	Belt 1.	2	3.	4.	5.	6.
Plot I.	0	100	7.61	100	0	64.70
Plot II.	33.33	100	In Crucifers.	100	75	87.50
Plot III.	100	100	In Beets.	100	100	100
Plot IV.	100	11.11	In Potatoes.	4.08	100	100

Fig. 9.

Results in Percentages of Second Turnip Crop for 1896.

In the five limed belts the yield was rather below the average for the series, but the percentage of clubbed roots was very light. The full and quarter-amount belts of Plot I. contained no clubbed roots, while in the half-amount belt 7.61 per cent. were slightly clubbed. Compared with the average of the five preceding crops the results are seen to be favorable to the last crop :

	Per Cent.	Per Cent.	Per Cent.
Average of first five crops.....	2.09	8.50	2.68
Second crop in 1896.....	0	7.61	0

The full-amount lime belts (600 bushels per acre) in Plot IV. contained 11.11 per cent. of clubbed roots, and the half-amount belt only 4.03 per cent. Compared with the first crop of 1896, there was seen to have been a decrease in the percentage of clubbed roots of 23.39 per cent. in the full-amount belt, and 39.72 per cent. in the half-amount belt. There was also a decided falling off in the percentage of clubbed roots as compared with the average of the three preceding crops upon the two belts here considered, as shown below :

	Per Cent.	Per Cent.
Average of first three crops.....	33.95	34.91
Second crop in 1896.....	11.11	4.03

In all the remaining belts of Plot IV. and in all the belts of Plot III. the percentage of clubbed roots was 100.

The two belts to which calcium carbonate and sodium carbonate had been applied yielded none but clubbed roots. The sodium carbonate proved somewhat injurious to the turnips, there being only about half a stand in the belt so treated. Of the other substances that had been added to the various belts, it need only be said that all failed, as they had previously done, to act as club-root fungicides.

SUMMARY.

Kainit applied in 1894 at the rate of 500 pounds per acre has given no results during the past three seasons as a club-root fungicide. Twice and four times the above amount of kainit has been found equally ineffective and besides proved harmful to the turnip plants.

Gas-lime either at the rate of 150 or 75 bushels per acre has been of no practical value as a club-root preventive. It does, however, seem to have some effect upon the development of the malady, since the increase in clubbing in the belts so treated has been less than in the checks.

Copper sulphate (bluestone) applied in powdered form in 1895 at the rate of 1,200 and 600 pounds per acre respectively, proved injurious to the turnip crop, and had no effect upon the club-root fungus.

Corrosive sublimate, when applied in solution, at the rate of 5,380 gallons per acre, seems to have been of value as a club-root fungicide previous to the present season. The last two crops upon the belt so treated have been badly clubbed. The same chemical applied in powdered form at the rate of 33.75 and 16.8 pounds per acre in 1895, has proved of no use as a fungicide, and in case of the larger amount was highly injurious to the plants.

Salt (sodium chloride) of the ordinary sort applied to two belts at the rate of 600 and 300 pounds per acre respectively, did not have any appreciable effect upon either the club-root or the turnips.

Sulphur applied the present season at the rate of 1,200, 600 and 300 pounds per acre respectively, had no apparent effect as a preventive of club-root. On the contrary, the percentage of clubbing was found to have increased in the three belts so treated, at essentially the same rate as in their respective check belts.

Calcium carbonate applied at the rate of 3,000 pounds per acre, just previous to the sowing of the second crop of 1896, did not reduce the percentage of clubbing.

Sodium carbonate applied at the same time and in the same amount as the calcium carbonate was equally ineffective as a club-root fungicide and proved harmful to the plants. A further trial of the two last-mentioned chemicals should be made before deciding upon their fungicidal merits.

Lime, freshly slaked, was applied to three belts of Plots I. in the spring of 1894 at the rate of 300, 150, and 75 bushels per acre, respectively. The largest application has continued to keep down the percentage of clubbing to almost nothing for the past three years, but the stand of turnips has, until the present season, been considerably reduced. The half and quarter-amount applications have proved almost as effective, as fungicides, and have not interfered with the growth of the plants, when the crop has been grown in its proper season.

In November, 1894, lime was applied to two belts in another and more thoroughly-infested portion of the series, at the rate of 600 and 300 bushels per acre, respectively. It was left upon the surface until spring, and then worked into the soil. The excessive amounts applied

did not injure the crops produced there, and the number of clubbed turnips was greatly diminished. The percentage of clubbing in the first crop of 1896 was considerably increased, which would seem to indicate that a second application was necessary.

Air-slaked stone-lime, therefore, has thus far proved to be the only substance of any practical value as a club-root preventive. Its use is recommended in amounts not greater than 150 nor less than 75 bushels per acre. The experiments thus far seem to indicate that the applications to severely-clubbed land in which turnips, cabbages or allied plants are yearly grown, should be made every other year. It is advisable to spread the lime upon the surface of the land in the fall and not turn it under until the following spring.

Further Experiments with Turnips.

In order to test the longevity of the club-root fungus in the soil, Plot I., Series IV., was sown to turnips upon April 21st and harvested upon the 22d of June. This plot had been in potatoes in 1894 and beans and celery in 1895, turnips having been grown there in 1892-93.

Belt 1.	2.	3.	4.	5.	6.	
126	125.5	111	99.5	122.5	120	Roots.
69	37	29	26	28	28	Sound.
58	88	78	67	88	77	Clubbed.
4.5	5.5	4	6.5	6.5	5	Bacterial Rot.
196	155	146	157	160	190	Tops.
322.5	280.5	257	256	282.5	310	Total.

Fig. 10.

Results in Pounds of the First Turnip Crop of Plot I., Series IV., in 1896.

The accompanying table (Figure 10) shows the yield of roots. It is seen at a glance that there is a large amount of clubbing. Of the total of 705 pounds of roots, 446 are clubbed and 32 pounds had a soft malodorous decay that is charged to some micro-organism and is termed "bacterial rot" in the table. Belt 5 received a liberal application of water, and the results show the largest percentage of clubbing and of bacterial decay of any of the belts.

This land test indicates that two years are entirely inadequate for the removal of the club-root fungus from the soil. In this case the ground was subjected to clean culture, and there was no opportunity for weeds that breed the disease to have aided in preserving the germs in the soil. While it is impossible to deduce from the single experi-

ment a principle to guide in the matter of crop rotation, the indications are that quite a number of years needs to elapse before land well charged with club-root germs will be suitable again for turnips or cabbages, unless direct soil treatment is practiced.

It was hoped that this soil, after the two years in other crops, might be comparatively free from the club-root, and for the second crop a series of soil inoculations with the club-root germs had been planned. They were, however, carried out, it being borne in mind that while there was a large percentage of the club-root it was very evenly distributed over the whole plot.

For this experiment, five bushels of thoroughly-clubbed turnips were selected at harvest time from the turnip series. All of the turnips were sliced through a root cutter, and one bushel was soaked two hours in corrosive sublimate solution of twice the standard strength (1 to 500), and then applied to belt 1 and spaded into the soil. To the next belt the bushel of clubbed roots was applied after having first been boiled for three hours. Upon belt 3 a bushel untreated was added, along with a quantity of manure. The next belt (4) was left without any application of roots and served as the check upon the other five belts. A bushel of the clubbed roots was fed to a heifer and the manure applied to belt 5, and upon belt 6 the turnips were applied without either previous treatment or manure.

The accompanying table (Figure 11) gives the results of this experiment. The extremely hot weather was unfavorable for the second crop of the early sort of turnip (Snowball) and the yield is small.

Belt 1.	2.	3.	4.	5.	6.	
13.5	24	11	28.5	9	9.25	Roots.
0	0	0	.5	0	0	Sound.
13.5	24	11	28	9	9	Clubbed.
2.5	7	2.5	7.5	2.25	2.25	Tops.
16	31	13.5	36	11.25	11.5	Total.

Fig. 11.

Results in Pounds of the Second Turnip Crop of Plot I., Series IV., in 1898.

It is seen that the largest yield in both tops and roots is upon the check belt, where no clubbed roots in any form were applied. This was the only belt yielding any sound roots. The next belt is where the turnips were boiled for three hours, the thought in this feature being to test the action of heat upon the germs, and it seems likely that they were thereby destroyed. The poorest crop was where the

manure from the animal fed upon clubbed roots had been applied, but there is only a little difference between this one and belt 6, where the same amount of roots was placed directly upon the land.

Box Experiment with Turnips.

With the exception of belt 1, with the corrosive sublimate, the above-detailed experiment was carried out in boxes in the greenhouse. The soil employed was that used generally in the greenhouse and not from the experiment area, and contained manure from mule stables located in the city. There is no likelihood that the soil contained any germs of club-root. Stated in the order of the belts in the corresponding plot in the field, omitting No. 1 for the corrosive sublimate, the boxes are: No. 2, to which the boiled turnips were applied; No. 3, bearing clubbed roots and fresh manure from cow stables; No. 4, the check; No. 5, manure from heifer fed with clubbed roots, and No. 6, simply clubbed roots added to the soil. These boxes were two feet square and the turnips came up by the hundred, and were afterwards thinned to about fifty. At the end of five weeks (June 25th to August 2d) the roots were pulled with the following results. Neither the check nor the box with the boiled pulp added showed any clubbing, while in the three having received the diseased roots all were badly clubbed and no difference in degree could be distinguished. Figure 12 is made from a photograph of a sample root from each of four boxes. Root No. 1 is from the check box, No. 2 from where manure and clubbed roots were added to the soil, No. 3 from where clubbed roots were added, and No. 4 from where the manure of a heifer fed upon clubbed roots was applied.

From this box experiment it may be inferred that with land perfectly clean of the germs, manure may become a vehicle for the transfer of the disease, and this suggests a caution in the use of diseased turnips for feeding farm animals.

Testing of Other Plants for Club-root.

In order to test the comparative susceptibility to club-root of other members of the mustard family, one belt in the turnip series was devoted to a long list of cruciferous plants. The land selected was the half-amount gas-lime belt, where the turnips for the four previous crops had been very badly clubbed and the soil must have contained a large amount of the fungus causing the disease.



Fig. 12.
Samples of Turnip Roots from the Box Experiments.

The following is the list of species that were tested. The rows ran the short way of the belt and after a row of each kind of seeds had been sown the series was duplicated upon the remaining half of the belt:

No.	Common Name.	Botanical Name.	Rank of the Clubbing.
1.....	Candytuft.....	(<i>Iberis umbellata</i> L.).....	11
2.....	Sweet alyssum.....	(<i>Alyssum maritimum</i> Lam.).....	12
3.....	Wild sweet alyssum.....	(<i>Alyssum alyssoides</i> L.)..	13
4.....	Shepherds' purse.....	(<i>Bursa Pastoris</i> L.).....	7
5.....	Rockcress.....	(<i>Arabis laevigata</i> (Muhl.) Poir.)..	4
6.....	Wormseed mustard.....	(<i>Erysimum cheiranthoides</i> L.)	5
7.....	Peppergrass.....	(<i>Lepidium Virginicum</i> L.).....	8
8.....	Field peppergrass.....	(<i>Lepidium campestre</i> Br.).....	6
9.....	Stock.....	(<i>Mathiola annua</i> Sw)	
10.....	Pennycress	(<i>Thlaspi arvense</i> L.).....	3
11.....	Cultivated radish.....	(<i>Raphanus sativus</i> L.).....	14
12.....	Rocket.....	(<i>Hesperis matronalis</i> L.).....	15
13.....	Black mustard.....	(<i>Brassica nigra</i> L.).....	9
14.....	Charlock.....	(<i>Brassica Sinapistrum</i> Bois.).....	1
15.....	White mustard.....	(<i>Sinapis alba</i> L.).....	2
16.....	False flax.....	(<i>Camelina sativa</i> (L.) Cranz).....	10

All but one (stocks) of the 16 species furnished roots that were more or less affected with the club-root. Charlock, so far as this experiment is concerned, was the most thoroughly infested, followed closely by the white mustard. There was remarkably less disease in the black mustard than in the two above named, for its rank was nine, as shown by the figure appended to each species. Pennycress was third in the list, rockcress fourth, wormseed mustard fifth, field peppergrass sixth, and so on. Among the kinds that were least affected were rocket, radish, the alyssums and candytuft.

EXPERIMENTS WITH POTATOES.

For the last three years, the series (II.) of the experiment area has been devoted to potatoes, the leading effort being to obtain a satisfactory remedy for the potato scab *Oospora scabies* Thax.*

That the reader may be prepared for the experiments and results of the present year, the plan of the series for the previous season is here introduced with some remarks upon the results therein shown.

* The reader will find in Bulletin No. 112 a general description of this pest, with an engraving of a badly-scabbed potato. Please also consult the reports for 1894, pages 291-295, and 1895, pages 267-275, giving full details of the potato experiments for the last two years.

	Belt 1.	2.	3.	4.	5.	6.
Plot I.	1894. Lime. 800 bushels. 1895. Scabby, 100 per ct. 184 pounds.	1895. Seed soaked 1 hour in corrosive sublimite (1-500). Scabby, 100 per ct. 115 pounds.	1894. Lime. 150 bushels. 1895. Scabby, 100 per ct. 150 pounds.	1895. Nothing. Scabby, 97 per ct. 126 pounds.	1894. Lime. 75 bushels. 1895. Scabby, 98 per ct. 188 pounds.	1894. Corrosive sublimite, 4,820 gallons. 1895. Scabby, 80 per ct. 108 pounds.
Plot II.	1894. Gas-lime. 150 bushels. 1895. Scabby, 100 per ct. 106 pounds.	1895. Seed soaked 1 hour in corrosive sublimite (1-1,000). Scabby, 100 per ct. 70 pounds.	1894. Gas-lime. 75 bushels. 1895. Scabby, 100 per ct. 108 pounds.	1895. Nothing. Scabby, 100 per ct. 108 pounds.	1894. Gas-lime. 37½ bushels. Scabby, 100 per ct. 90 pounds.	1894. Bordeaux. 4,820 gallons. 1895. Scabby, 70 per ct. 107 pounds.
Plot III.	1894. Kainit, 1,920 pounds. 1895. Scabby, 100 per ct. 138 pounds.	1895. Seed soaked 1 hour in corrosive sublimite (1-2,000). Scabby, 100 per ct. 186 pounds.	1894. Kainit. 960 pounds. 1895. Scabby, 100 per ct. 126 pounds.	1895. Nothing. Scabby, 100 per ct. 144 pounds.	1894. Kainit. 480 pounds. 1895. Scabby, 100 per ct. 125 pounds.	1894. Cupram. 4,820 gallons. 1895. Scabby, 80 per ct. 104 pounds.
Plot IV.	1894. Ashes. 800 bushels. 1895. Scabby, 100 per ct. 181 pounds.	1895. Seed soaked 1 hour in corrosive sublimite (1-4,000). Scabby, 100 per ct. 138 pounds.	1894. Ashes. 150 bushels. 1895. Scabby, 100 per ct. 126 pounds.	1895. Nothing. Scabby, 100 per ct. 116 pounds.	1894. Ashes. 75 bushels. 1895. Scabby, 100 per ct. 120 pounds.	1895. Sulphur. 800 pounds. Scabby, 5 per ct. 101 pounds.

Fig. 13.

Plan and results of Potato Experiments at College Farm for 1895.

During the year 1895 an acre of land in a section of the State (Freehold) where the scab had caused a failure of the crop the previous year, was experimented upon and the results from this field and those of the home series are here condensed. In the Freehold experiment six substances were tested, namely, lime, sulphur, manure, corrosive sublimate, kainit and copper sulphate, each being used in three amounts upon as many separate plots.

In the series at the College Farm the diagram shows that scab abounded, all the potatoes being marked upon nearly every belt. As the land had been in cabbages the year before and treated for club-root with lime, gas-lime, kainit and wood-ashes, these substances are recorded for their respective belts in the diagram given for the potato crop that followed directly upon the cabbage. It will be seen that lime in all three of its amounts proved no remedy for the scab. The same results were obtained for lime from the Freehold experiments,

and they accord with those from other Experiment Stations in various parts of the United States. Manure, it was shown, tends to increase the amount of the scab, it being 60 per cent. as against 47 where no manure was used.

In the Freehold experiments the kainit showed strong fungicidal effects. The plots with the three chemicals that alternated with the three fertilizers all had less scab than the plots receiving nothing, sulphur leading, with corrosive sublimate and copper sulphate third.

The experiments upon the home series confirm the results obtained at Freehold in a most emphatic manner, so far as sulphur is concerned, for in the belt upon which it was used at the rate of 300 pounds per acre, the potatoes were nearly free from scab, while the control belts averaged nearly 100 per cent. On the other hand, the corrosive sublimate used in the ordinary way, tested in four different strengths, failed to show any less scab than the untreated seed.

The report of the results of experiments with the potato scab closed last year with the following words: "For the Irish potatoes, it is suggested that the flowers of sulphur, costing two or three cents a pound, be used with the freshly-cut seed in the hopper of the planting machine."

Before taking up the experiments for the present year, it may be said in passing that the results for 1895 were so encouraging that large numbers of potato-growers throughout New Jersey and in other States acted upon them and used sulphur as a preventive of the scab. Many such growers have reported excellent results, some of them being highly gratified with their returns. No one has expressed any word that has not been in confirmation of the original experiments. In short, the growers were so willing to test the sulphur for themselves that there seemed no need for the Experiment Station to conduct further trials throughout the State.

Experiments in 1896.

Some changes were made upon the potato series of the experiment area from those of the previous year, chiefly in the increase in the number of belts receiving sulphur, the addition of more kainit belts, the introduction of the "Early Rose" and "American Giant" sorts as a variety test for the scab and four belts were irrigated.

The accompanying plan gives the treatments each belt has received for the past two seasons.

	Belt 1.	2.	3.	4.	5.	6.
Plot I.	1894. Lime. 800 bushels. 1895. Scabby. 110 per ct. 184 pounds. 1896. *Scabby 75 per ct. 88 pounds.	1895. Seed soaked 1 hour in corrosive sublimite (1-300). Scabby. 100 per ct. 115 pounds. 1896. Sulphur. 120 pounds. Scabby. 50 per ct. 76 pounds.	In Turnips and Beets.	1895. Nothing. Scabby. 97 per ct. 126 pounds. 1896 (Early Rose). Scabby. 85 per ct. 55 pounds.	1894. Lime. 75 bushels. 1895. Scabby. 95 per ct. 133 pounds. 1896. Irrigated. Scabby. 75 per ct. 76 pounds.	1894. Corrosive sublimite. 4,820 gallons. 1895. Scabby. 80 per ct. 108 pounds. 1896. Corrosive sublimite. 4,820 gallons. Scabby. 10 per ct. 81 pounds.
Plot II.	1894. Gas-lime. 150 bushels. 1895. Scabby. 100 per ct. 105 pounds. 1896. Scabby. 75 per ct. 109 pounds.	1895. Seed soaked 1 hour in corrosive sublimite (1-1,000). Scabby. 100 per ct. 70 pounds. 1896. Sulphur. 240 pounds. Scabby. 50 per ct. 109 pounds.	1894. Gas-lime. 75 bushels. 1895. Scabby. 100 per ct. 108 pounds. 1896. Kainit. 600 pounds. Scabby. 45 per ct. 83 pounds.	1895. Nothing. Scabby. 100 per ct. 103 pounds. 1896. Scabby. 70 per ct. 75 pounds.	1894. Gas-lime. 37½ bushels. 1895. Scabby. 100 per ct. 90 pounds. 1896. (Am. Giants). Irrigated. Scabby. 50 per ct. 26 pounds.	1894. Bordeaux. 4,820 gallons. 1895. Scabby. 70 per ct. 107 pounds. 1896. Bordeaux. 4,820 gallons. Scabby. 50 per ct. 64 pounds.
Plot III.	1894. Kainit. 1,920 pounds. 1895. Scabby. 100 per ct. 133 pounds. 1896. Scabby. 85 per ct. 92 pounds.	1895. Seed soaked 1 hour in corrosive sublimite (1-2,000). Scabby. 100 per ct. 186 pounds. 1896. Sulphur. 600 pounds. Scabby. 65 per ct. 88 pounds.	1894. Kainit. 900 pounds. 1895. Scabby. 100 per ct. 126 pounds. 1896. Kainit. 1,200 pounds. Scabby. 70 per ct. 19 pounds.	1895. Nothing. Scabby. 100 per ct. 144 pounds. 1896 (Am. Giants). Scabby. 75 per ct. 84 pounds.	1894. Kainit. 480 pounds. 1895. Scabby. 100 per ct. 126 pounds. 1896. Irrigated. Scabby. 85 per ct. 107 pounds.	1894. Cupram. 4,820 gallons. 1895. Scabby. 80 per ct. 104 pounds. 1896. Cupram. 4,820 gallons. Scabby. 75 per ct. 87 pounds.
Plot IV.	1894. Ashes. 800 bushels. 1895. Scabby. 100 per ct. 181 pounds. 1896. Seed soaked 2 hours in corrosive sublimite (1-500). Scabby. 90 per ct. 69 pounds.	1895. Seed soaked 1 hour in corrosive sublimite (1-4,000). Scabby. 100 per ct. 133 pounds. 1896. Seed rolled in sulphur. Scabby. 90 per cent. 99 pounds.	1894. Ashes. 150 bushels. 1895. Scabby. 100 per ct. 126 pounds. 1896. Seed soaked 2 hours in kainit (1-100). Scabby. 80 per cent. 67 pounds.	1895. Nothing. Scabby. 100 per ct. 116 pounds. 1896. Scabby. 90 per ct. 90 pounds.	1894. Ashes. 75 bushels. 1895. Scabby. 100 per ct. 120 pounds. 1896. (Early Rose). Irrigated. Scabby. 100 per ct. 84 pounds.	1895. Sulphur. 800 pounds. Scabby. 5 per ct. 101 pounds. 1896. Scabby. 5 per ct. 82 pounds.

Fig. 14.

Plan and results of Potato Experiments at College Farm for 1896.

*In 1895 the percentage of scabiness was determined by the presence of the scab upon each potato, and in 1896 the amount of scab taken as a whole. That is, in 1895 one hundred per centum meant that every tuber was more or less scabby, but the present year it was thought best to change the basis of the percentages to the amount of scabiness, the worst belt, where all the potatoes were almost literally covered with scabs, being taken as representing the 100 per cent., and all other belts were compared with that one.

It will be seen at a glance that scab was common to the field and most abundant in the lower plots, a fact that has obtained for the three years the series has been in potatoes. The largest amount of scab was with the Early Rose variety, the belt in this sort in Plot IV. being taken as the maximum of 100 per cent. with which to compare the other belts. The Giants were planted in two belts, that this variety, sometimes mentioned as exempt from the scab, might be fully tested as to its susceptibility. While it is a fact that the scab does not work as deeply in this variety as in the Early Rose, it is true that when placed in a scabby soil the Giants will scab badly, as the percentages for its belts will show in the diagram. Of the three varieties represented in the series, the Early Rose is the most susceptible and the Giants the least, with the Rural No. 2 taking a position midway between them. It is not, of course, demonstrated in this experiment, but the indications are strongly in favor of the opinion that no variety of the Irish potato is absolutely exempt from attacks of the scab fungus. The degree of susceptibility may reside in the characteristics of the outer layer of the tuber.

Turning to Plot I., it is seen that in the belt (1) with lime of three years' residence in the soil, the yield was very small and poor. The adjoining belt with sulphur, 120 pounds per acre, added, gave a fair yield and the scabbiness much reduced. The belt in this plot, with corrosive sublimate added to the soil, gave the smallest yield of all the belts in the field, but the potatoes were but little marked with the scab. In Plot II., the best belt by large odds is the one receiving the sulphur, 240 pounds per acre, followed by the one with kainit. The largest yield in Plot III. is upon the irrigated belt, where the scab is very severe. Here again the best results, considering both yield and scabbiness, are in the belt receiving the sulphur. Plot IV. represents the end of the area of potato ground that has the largest percentage of scab. Here the seed treatment was made with corrosive sublimate, sulphur and kainit, leaving one check, one for irrigation and one where sulphur was added to the soil for the previous crop. It will be seen that the worst potatoes were in the irrigated belt, which were literally covered with deep patches of scab. There was no noticeable difference between the belts treated with corrosive sublimate (1 to 500 for two hours), sulphur and the check, although the largest yield was upon the one with the sulphur. The kainit belt gave a lower yield and somewhat smaller percentage of scab. The most striking fact in this plot is the good-sized crop of potatoes, and

almost entirely free from scab, produced upon the belt that received sulphur, three hundred (300) pounds per acre, in 1895. This seems to be entirely the result of the lasting fungicidal effects of sulphur. It will be seen by a glance at the diagram that the adjoining belt had 100 per cent., while this gave only 5 per cent. of scab.

Bordeaux and cupram were again added to their respective belts, and show good results in checking the scab. Aside from these standard fungicides for spraying, the results indicate that for soil treatment for the scab, sulphur takes the lead, that its good effect is lasting when added to the soil; but when the soil is badly infested, there is no hope of checking it successfully by simply rolling the seed in the sulphur. This is a good thing to do in addition to the sprinkling in the open row, for experiments show that instead of injuring the freshly-cut "seed" it keeps it from drying out, and might well replace land plaster for this purpose when "seed" is cut some time before planting.

The experiments indicate that corrosive sublimate will check the scab when the soil is badly infested, but the mere soaking of the seed is ineffective and it needs to be added to the soil. The proper amount is not determined, for the quantity employed proved injurious to the crop and a very light yield resulted, mostly from a replanting of missing hills. The same failure of the plants to come up well was experienced with the kainit belts, and here while the scab was checked the yield was light.

It is not unlikely that a proper amount of kainit mixed with sulphur, about 300 pounds of the former to an equal weight of the latter, would give a combination of fungicide and fertilizer that may prove of great value on the scab-infested farms of the potato-growing regions of our State.

Two engravings from photographs have been made from the crops of five belts the present year that correspond with those published in the last report. Figure 15 shows the largest 25 tubers from the corrosive sublimate, Bordeaux, cupram, nothing and sulphur belts.

The interested reader may find it instructive to compare this with the engraving (Figure 21) in last year's report of similar piles from the same belts. The relative amounts of scab upon the potatoes hold nearly the same during the two years.

The duplicate of Figure 22 of last year's report is shown in Figure 16, it being remembered that the good effect of the sulphur shown in the engraving is after the fungicide has been in the soil since the spring of 1895.

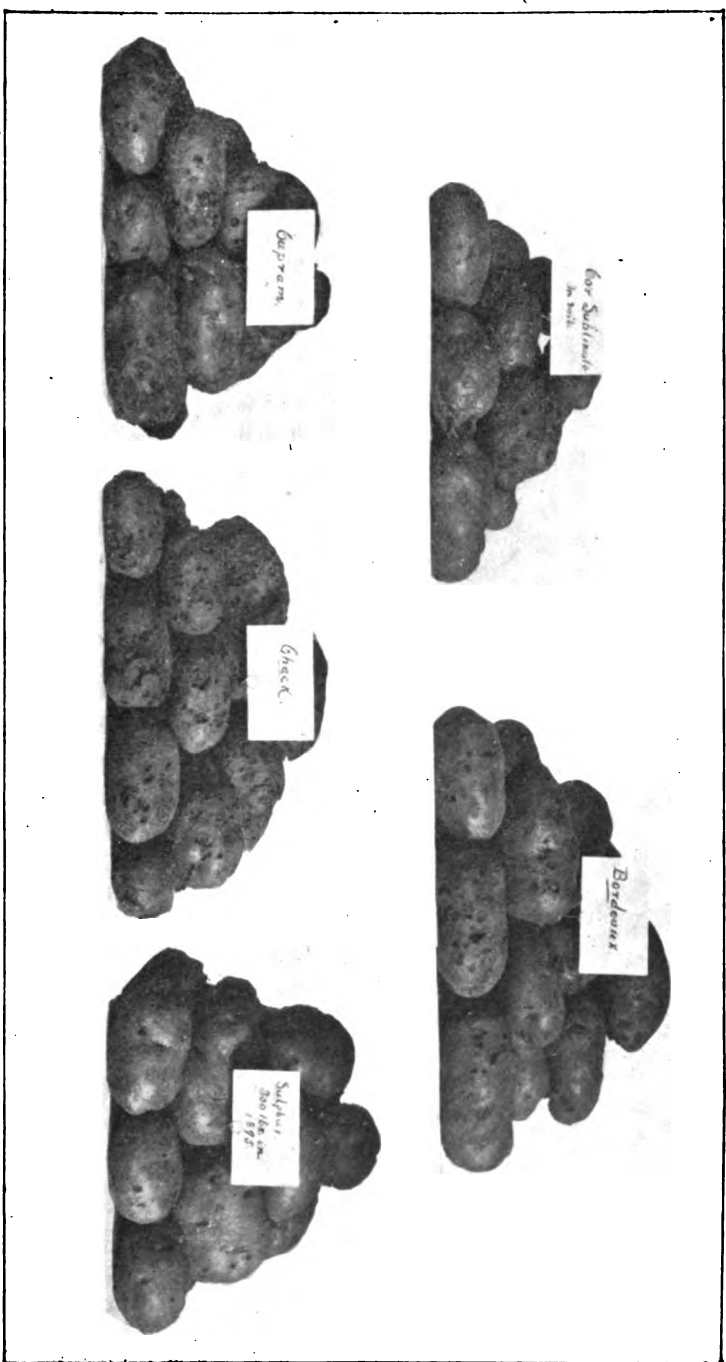


Fig. 15.

Engraving from a photograph, showing the largest twenty-five potatoes from the Corrosive Sublimite, Bordeaux Gypsum cheek and Sulphur balls.

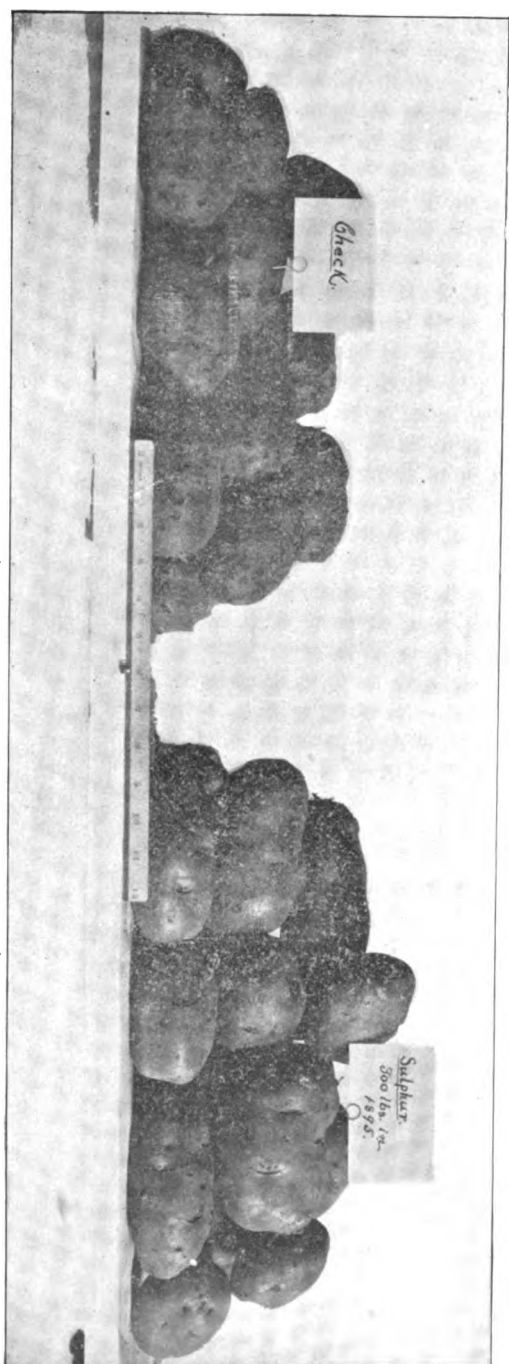


Fig. 16.
A larger view of the Check and Sulphur Piles.

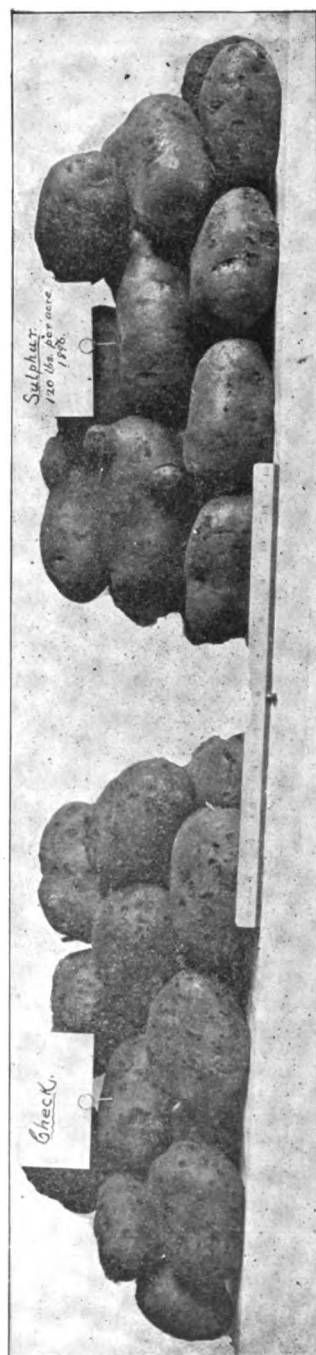


Fig. 17.
Potatoes grown with 120 pounds of Sulphur per acre, applied the present season.

In addition to the above, Figure 17 shows the contrast between the check and a belt receiving 120 pounds of sulphur per acre for the present year. The sulphur in this case was applied to a soil where the potatoes the season before were 100 per cent. scabby.

Further Experiments with Potatoes.

Opportunity offered in three plots for testing the value of different methods of cutting the "seed," and also of depths in planting. The three plots received the same treatment, but each was with a different

	Belt 1.			2.			3.			4.			5.			6.		
	Bud Ends.			Middles.			Stem Ends.			Middles.			Middles (Irrigated).			Middles (Depths).		
	20	18	20	20	20	20	20	17	20	21	21	21	19	19	20	8 in	6 in	4 in
Number of plants.....	20	18	20	20	20	20	20	17	20	21	21	21	19	19	20	19	21	21
Weight of plants.....	26.5	26	23	24	22	22	23.5	11	19	30	32.5	32.5	34.5	20	33	28.5	26	32
Weight of tubers.....	20.5	24.5	21	26.5	23	26	19	17.5	19	22.5	26	23.5	33	31	29.5	20	26	21.5
Weight of scabbed.....	20.25	24	17.5	26	26.5	26.5	13.5	15.5	16.5	19	23.5	22	20	24	23	13.5	23.5	13.5
Weight of unscabbed..	.26	.5	3.5	.5	0	.5	.5	2	2.5	3.5	1.5	1.5	13	7	6.5	1.5	4.5	3
Total tubers by belts..	66			80.5			56.5			71			93.5			69.5		

Fig. 18.

Results of Further Experiments with Potatoes—Early Rose.

variety of potato, the following being employed, namely, "Early Rose," "American Giants," and "Rural No. 2." The first belt in each plot was planted with the bud end of the potatoes; belt 2 with the

middle pieces, and belt 3 with cuts from the stem end. All the other three belts in each plot were planted with the middle pieces, and one belt (5) was irrigated; another (6) had the potatoes planted at different depths, while the remaining belt (4) was untreated. Mulch was applied to one row in each belt, and therefore the results are given in the table by rows, as well as by belts, three rows making a belt. The matter of the mulching is treated of under a separate general heading of this report.

	Belt 1.			2.			2.			2.			4.			5.			6.		
	End Enda.			Middlea.			Stem Enda.			Middlea.			Middlea.			Middlea. (Irrigated).			Middlea. (Depths).		
	18	20	18	20	18	20	15	19	15	20	21	18	17	19	21	18	19	21	8 in	6 in	4 in
Number of plants.....	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18	18	17
Weight of plants.....	4	6	10.5	6	9.5	—	6.5	9	6	12	13.5	10	13	11	16.5	11	—	—	11	4	—
Weight of tubers.....	12.5	11	14	22	16	17	9	12.5	9.5	12.5	13	13	14.5	20	16	9.5	8	4.5	—	—	—
Weight of scabbed.....	2	2	3	5.5	4	2	1	1	2.5	2	2.5	1.5	2.5	6	8.5	7.5	5	3	—	—	—
Weight of unscabbed...	10.5	9	11	16.5	12	15	8	11.5	7	10.5	17.5	11.5	12	14	7.5	2	3	1.5	—	—	—
Total tubers by belts..	37.5	55	—	—	—	—	31	43.5	50.5	22	—	—	—	—	—	—	—	—	—	—	—

Fig. 19.

Results of Further Experiments with Potatoes—American Glans.

It will be seen that with the "Early Rose," the first variety to be harvested (August 5th), the greatest yield was upon the irrigated belt, and here also the potatoes free from scab are in excess of those upon

any other belts. The smallest yield was in the belt where the stem ends were planted, and in this plot all of the belts where the middle pieces were used the yield was better than in either the bud or stem-end belts.

In the depths belt, the row with seed planted six inches below the surface gave the best yield of the three depths tested, but it was no better than the rows of normal depth elsewhere in the plot.

	Belt 1.			2.			3.			4.			5.			6.		
	Bud Ends.			Middles.			Stem Ends.			Middles.			Middles (Irrigated).			Middles (Depths).		
	20	20	20	17	19	21	21	19	20	20	21	21	20	21	20	8 in	6 in	4 in
Number of plants.....	20	20	20	17	19	21	21	19	20	20	21	21	20	21	20	19	20	16
Weight of plants.....	9.5	5	8.5	5	5	4.5	12	10.5	15.5	11	6.5	10.5	7	6.5	6.5	9	10.5	10
Weight of tubers.....	32	32	30	42	42.5	30	35	37	28.5	37	41.5	37	33	40	41.5	25	29.5	24
Weight of scabbed.....	17	11.5	5.5	12.5	12	6	21.5	29.5	24	34.5	41.5	36.5	30.5	36.5	39	23	27	23
Weight of smooth.....	15	20.5	24.5	29.5	30.5	33	13.5	7.5	4.5	2.5	0	.5	2.5	3.5	2.5	2	2.5	1
Total tubers by belts.....	91			123.5			100.5			115.5			114.5			78.5		

Fig. 20.

Results of Further Experiments with Potatoes—Rural No. 2.

The plot of "American Giants" was next harvested (August 14th) with a small comparative yield.

The largest yield was upon an unirrigated belt planted with middle pieces and the smallest yield was upon the depths belt, with the next

poorest where the stem ends were planted. In this plot the largest percentage of scab was upon the irrigated belt. No satisfactory results were obtained for either of the depths in planting.

The third plot, Rural No. 2, harvested August 26th, gave the largest yield of all the plots, and again the belts planted with middle pieces were ahead. The scab was greatest upon the check belt, followed closely by its adjoining belt under irrigation.

By taking the left-hand half of each of the three plots where the experiment of cutting the seed was carried out, it is seen that belt 2, where the middle portions of the seed potatoes were used, gives in each trial the largest yield.

	Bud End.	Middle.	Stem End.
Early Rose.....	66	80.5	55.5
American Giant.....	37.5	55	31
Rural No. 2.....	94	123.5	100.5
Totals	197.5	259	187

While there is no practical difference between the two ends, the uniform increase for the middle pieces would suggest that the end cuts might be discarded when the seed is prepared for planting.

If belt 2 is compared with the irrigated belt, the two being alike in all things save the water received, it is seen that the total yield is almost exactly the same, namely, belt 2, 259 pounds; irrigated, 258.5, while the scabbed potatoes are 123.5 and 190 pounds, or a very large increase of the diseased tubers on the irrigated belt.

The test with depths of planting does not give any indications of an advantage in varying from the normal depth. The results for the three plots for each depth are as follows:

	Depth, 8 inches.	Depth, 6 inches.	Depth, 4 inches.
Early Rose	20 pounds.	28 pounds.	21.5 pounds.
American Giant.....	9.5 "	8 "	4.5 "
Rural No. 2	25 "	29.5 "	24 "
Totals.....	54.5 pounds.	65.5 pounds.	50 pounds.
Total scabbed.....	49 "	55.5 "	44.5 "
Clean Potatoes.....	5.5 "	10 "	5.5 "

There is considerable additional labor in both the planting and harvesting where the depth is more than four inches, and the gain does not seem to justify the increase in cost.

Potatoes in the Turnip Land.

One of the belts in the land devoted to turnips was planted to Rural No. 2 to determine whether a long series of club-rooted crops of turnips would have any influence upon another widely dissimilar "root" crop. The weight of tubers was 136 pounds, a larger yield than the same variety gave upon any belt elsewhere; but the most striking fact obtained is that only a single pound was entirely free from the scab. Here is a case where land had not been in potatoes for at least six years, and the crop was practically worthless.

EXPERIMENTS WITH SWEET POTATOES.

In 1895 experiments were made with sweet potatoes upon the farm of Mr. George W. Jessup, Cinnaminson, N. J., for the purpose of finding some preventive of the soil rot.* There were six series of plots in the field, three of them receiving fertilizers, namely, lime, manure, and kainit, and three others alternating with these which received chemicals that it was hoped might check the soil rot, namely, sulphur, corrosive sublimate and copper sulphate. The arrangement of the experiment offered an opportunity for combining the materials in pairs and for leaving sufficient check plots. The accompanying plan (Figure 21) shows the whole arrangement, and from it, it will be seen that the first plot to the left, in each series, received the largest amounts of the substance; the middle row of plots (up and down), half those amounts, respectively, and a quarter as much was applied to the corresponding plots at the right end in each series. Combinations were made between half-amounts in the row of plots lying between full and half-amounts, and quarter-amounts were in combination in the plots lying between the half and quarter-amounts, as indicated in the headlines of the diagram. In Series I., the amount of lime was large—a thousand bushels per acre in the left hand-plot.†

*For a consideration of this disease and engravings showing the trouble, the reader is referred to Bulletin No. 112, pages 13-20, and the Annual Report for 1895, pages 276-283.

†A young pear orchard had been set upon the land and the size and shape of the plots were modified thereby, each being one-thirtieth instead of one-fiftieth of an acre, as in the original plan. The materials to be used had been purchased and parceled out, so that the amounts in all plots were larger than originally contemplated.

	Full Amounts.	Half Amounts.	Quarter Amounts.
Series I. Lime.	Slaked lime, 1,000 bushels. Stand, 80 per cent. Yield, 19 pounds clean; 21 pounds marked.	Check. Stand, 63 per cent. Yield, 17 pounds clean; 22 pounds marked.	Lime, 250 bushels. Stand, 98 per cent. Yield, 28 pounds clean; 18 pounds marked.
Series II. Flowers of sulphur.	Sulphur, 2,500 pounds. Stand, 55 per cent. Yield, 47 pounds clean; 17 pounds marked.	Lime, 500 bushels; sulphur, 1,250 pounds. Stand, 15 per cent. Yield, 4 pounds clean; 5½ pounds marked.	Sulphur, 625 pounds. Stand, 94 per cent. Yield, 68 pounds clean; 38 pounds marked.
Series III. Manure.	Manure, 11 tons. Stand, 30 per cent. Yield, 1 pound clean; 12 pounds marked.	Check. Stand, 30 per cent. Yield, 1 pound clean; 16 pounds marked.	Manure, quarter amount. Stand, 60 per cent. Yield, 2½ pounds clean; 82 pounds marked.
Series IV. Corrosive sublimite.	Corrosive sublimite, 500 pounds. Stand, 100 per cent. Yield, 57 pounds clean; 29 pounds marked.	Manure, half amount; corrosive sublimite, 100 pounds. Stand, 86 per cent. Yield, 81 pounds clean; 28 pounds marked.	Corrosive sublimite, 50 pounds. Stand, 72 per cent. Yield, 29 pounds clean; 41 pounds marked.
Series V. Kainit.	Kainit, 5,000 pounds. Stand, 30 per cent. Yield, 9 pounds clean; 16 pounds marked.	Check. Stand, 80 per cent. Yield, 19 pounds clean; 40 pounds marked.	Kainit, 1,250 pounds. Stand, 40 per cent. Yield, 5 pounds clean; 28 pounds marked.
Series VI. Sulphate of copper.	Sulphate of copper, 500 pounds. Stand, 60 per cent. Yield, 24 pounds clean; 28 pounds marked.	Kainit, 2,500 pounds; sulphate of copper, 250 pounds. Stand, 75 per cent. Yield, 30 pounds clean; 33 pounds marked.	Sulphate of copper, 125 pounds. Stand, 45 per cent. Yield, 16 pounds clean; 36 pounds marked.

Fig. 21.

Plan and results of Field Experiments for Soil Rot of Sweet Potatoes at Chinnaminson in 1895.

It was desired to determine how much lime the crop would bear, and the result shows that the poorest stand of plants in this series was in the plot where no lime was used, and adjoining the one receiving the largest amount. In the sulphur series, the stand of vines increases as the amount of sulphur diminishes, and it is not unlikely that the applications were too large, and, of course, such quantities were not expected to be practicable. The manure did not affect the stand materially, it being an unusually dry season, and at best the crop upon any plot in the whole field was small. With corrosive sublimate the stand was full with the plot receiving the largest amount and decreased as the quantity diminished. In the kainit and copper sulphate series no effect was recorded.

The potatoes at harvesting were all inspected and assorted into those marked with soil rot and those that were clean. No other form of rot was present in sufficient amount to enter into the problem.

The following table of averages was constructed, followed by averages of combinations, shown by the figures opposite the braces :

	Pounds of Clean Roots.	Pounds of Marked Roots.	Clean.	Marked.
Lime	25	21	15	8
Sulphur	55	22		
Manure	4	25	18	30
Corrosive sublimate	49	32		
Kainit	8	26	17	30
Sulphate of copper	18	40		
Check	9	29		

Two of the six series, namely, manure and kainit, give poorer results than the plot where nothing was used. Sulphur gives the highest yield of clean roots, followed closely by the corrosive sublimate. While the figures do not differ greatly, there are factors not to be stated by them; for example, the potatoes from the sulphur plots are very smooth and fair, free from scurf, crooks and disfigurements, while quite the opposite is true of those from the corrosive sublimate belts. Further, the cost of the sulphur is half that of the corrosive sublimate, to say nothing of the intensely poisonous, and therefore dangerous nature of the latter substance.

Experiments with Sweet Potatoes the Present Year.

The field of Mr. Jessup's, outlined above, was continued in sweet potatoes, this making the third successive crop attempted upon the land. The whole area was fertilized uniformly throughout, and no other additions were made to any plot, the point being to determine the lasting effects of the various substances that had been applied the previous year.

From the accompanying plan of results (Figure 22), some points of interest may be drawn. The season was a fair one as regards rainfall, and the crop was much larger than the previous year. There was, however, a decrease in the stand upon some of the plots, this being confined quite closely to those receiving the larger amounts of lime. Thus, the stand is lowest, 40 per cent., where the lime was 1,000 bushels, and only 55 per cent. where it was 500 bushels per acre the previous season. It was but little better, 60 per cent., where the 500 bushels were combined with 1,250 pounds of sulphur per acre, and but 75 per cent., far below the average, where lime was used at the rate of 250 bushels and sulphur 625 pounds per acre. Lime alone at the rate of 250 bushels reduced but little the stand of the plants.

Sulphur had no material effect upon the growth of the vines, the stand being 98 per cent. in all the three plots, and in short, in all the six series excepting lime, the treated plots averaged in the stand of plants as high as their checks.

The table of averages of clean and marked roots, constructed to correspond with that made for the previous year, is as follows :

	Pounds of Clean Roots.	Pounds of Marked Roots.	Clean.	Marked.
Lime.....	25	75 }	31.5	63
Sulphur.....	107	34 }		
Manure.....	89	54 }	63	83
Corrosive sublimate	83	72 }		
Kainit.....	80	79 }	94	59
Copper sulphate.....	63	48 }		
Checks.....	48	69		

This table shows two things at the first glance, namely, that lime is not a preventive of the soil rot, and that of all the substances tested sulphur is the best remedy for the disease.

	Full Amounts.	Half Amounts.	Quarter Amounts.
Series I. Lime.	Slaked lime, 1,000 bushels. Stand, 40 per cent. Yield, 8 pounds clean; 66 pounds marked.	Check. Stand, 90 per cent. Yield, 80 pounds clean; 70 pounds marked.	Lime, 250 bushels. Stand, 96 per cent. Yield, 40 pounds clean; 116 pounds marked.
Series II. Flowers of sulphur.	Sulphur, 2,500 pounds. Stand, 98 per cent. Yield, 81 pounds clean; 7 pounds marked.	Lime, 500 bushels. sulphur, 1,250 pounds. Stand, 98 per cent. Yield, 60 per cent. Yield, 13 pounds clean; 61 pounds marked.	Sulphur, 625 pounds. Stand, 96 per cent. Yield, 130 pounds clean; 46 pounds marked.
Series III. Manure.	Manure, 11 tons. Stand, 90 per cent. Yield, 60 pounds clean; 57 pounds marked.	Check. Stand, 90 per cent. Yield, 45 pounds clean; 83 pounds marked.	Manure, quarter amount. Stand, 98 per cent. Yield, 129 pounds clean; 40 pounds marked.
Series IV. Corrosive sublimite.	Corrosive sublimite, 200 pounds. Stand, 95 per cent. Yield, 79 pounds clean; 80 pounds marked.	Manure, half amount; corrosive sublimite, 100 pounds. Stand, 98 per cent. Yield, 46 pounds clean; 123 pounds marked.	Corrosive sublimite, 60 pounds. Stand, 98 per cent. Yield, 68 pounds clean; 102 pounds marked.
Series V. Kainit.	Kainit, 5,000 pounds. Stand, 95 per cent. Yield, 45 pounds clean; 62 pounds marked.	Check. Stand, 95 per cent. Yield, 43 pounds clean; 69 pounds marked.	Kainit, 1,250 pounds. Stand, 90 per cent. Yield, 114 pounds clean; 86 pounds marked.
Series VI. Sulphate of copper.	Sulphate of copper, 500 pounds. Stand, 90 per cent. Yield, 60 pounds clean; 19 pounds marked.	Kainit, 2,500 pounds; sulphate of copper, 250 pounds. Stand, 98 per cent. Yield, 54 pounds clean; 66 pounds marked.	Sulphate of copper, 125 pounds. Stand, 90 per cent. Yield, 75 pounds clean; 55 pounds marked.

Fig. 22.

Plan and results of Field Experiments for Soil Rot of Sweet Potatoes for 1896.

The totals, in pounds, of the several substances run as follows :

Lime	100
Lime and sulphur.....	94.5
Sulphur	141
Manure	143
Corrosive sublimate.....	155
Manure and corrosive sublimate.....	146
Kainit	159
Copper sulphate.....	111
Kainit and copper sulphate	153
Checks	117

By deducting $33\frac{1}{3}$ per cent. from the "marked" roots, a fair representative of the marketable crop for each substance is as follows :

	Marketable. Crop.	Rank.
Lime.....	75 pounds.	7
Sulphur	118 "	1
Lime and sulphur.....	52.5 "	9
Manure	107 "	4
Corrosive sublimate.....	107 "	4
Manure and corrosive sublimate.....	91 "	5
Kainit.....	109 "	3
Copper sulphate.....	82 "	6
Kainit and copper sulphate.	114 "	2
Checks.....	71 "	8

From this it is seen that only one substance falls below the check plots, namely, lime, whether it be alone or in combination with sulphur. The sulphur is closely followed by kainit when in combination with copper sulphate and third when alone. Manure and corrosive sublimate are equal, and when combined are nearly as good, the three sets forming the middle Nos. 4, 5 and 6 of the series of ranks, Copper sulphate alone gives nothing to encourage its use, and lime stands condemned as a preventive of soil rot.

The results of this second year show that there are marked differences in the properties of the compounds to check the soil rot. Sulphur maintains its first place and kainit has given results that warrant further experiments with it.

Upon the same field the coming year, some of the check plots will receive kainit and others kainit and sulphur combined, in the hope that with this a fertilizer-fungicide may be obtained that will be better than when either substance is used alone.

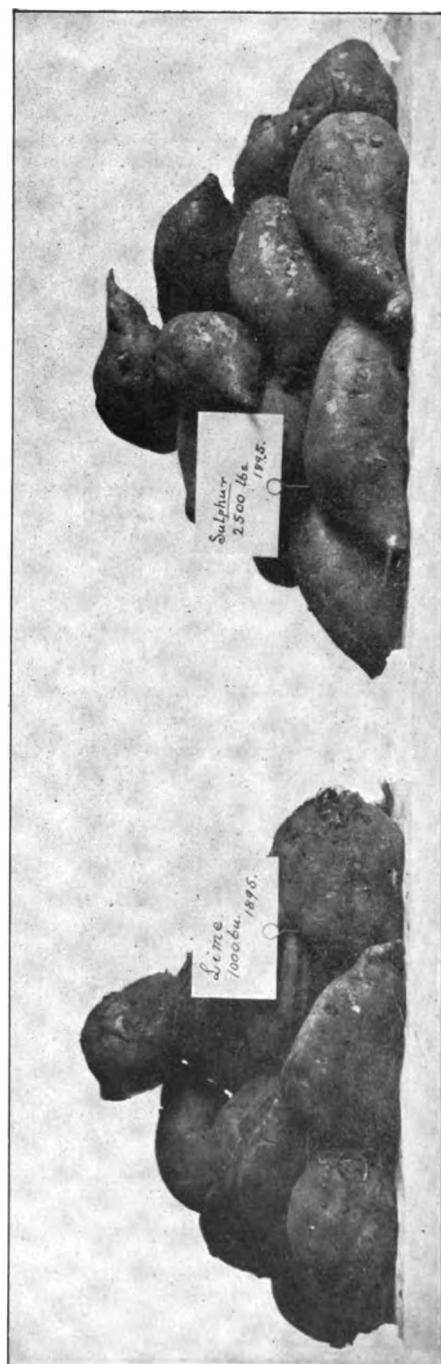


Fig. 24.
A larger view of the Lime and Sulphur belts.

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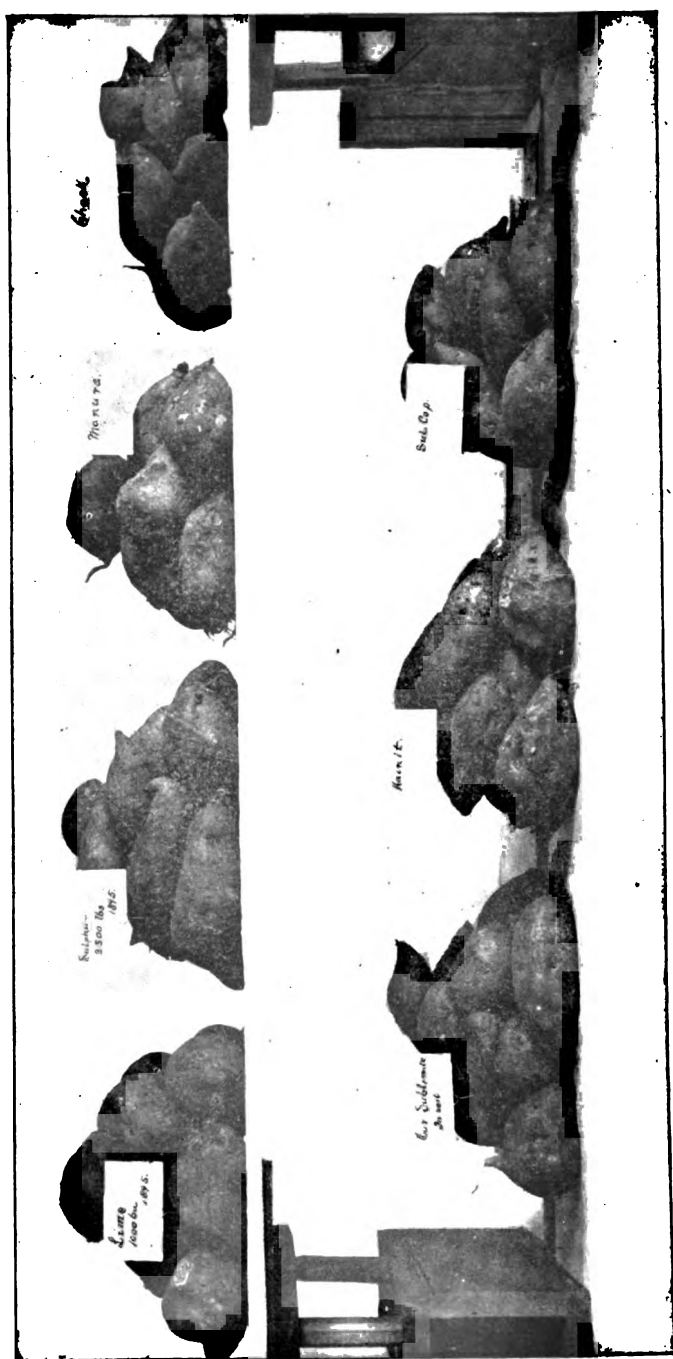


Fig. 23.

From a photograph of the largest potatoes from Lime, Sulphur, Manure, Check, Corrosive Sublimate, Kalnit and Sulphate of Copper belts.

Figure 23 shows the largest twenty-five sweet potatoes from seven of the plots, namely, where lime, sulphur, manure, check, corrosive sublimate, kainit and sulphate of copper were applied the previous year. This engraving corresponds with Figure 26 of the report for 1895. The two sets show almost parallel results, the roots from the limed ground being shorter than those produced elsewhere, while the fairest and best potatoes grew upon the plot receiving sulphur in 1895. The hold-over effect of the sulphur is more striking than that produced the first season.

A larger view of the piles from the sulphur and lime belts is shown in Figure 24, and corresponds with Figure 27 of the report of last year. The results for the two seasons upon the same pair of plots are similar.

Additional Experiments with Sulphur.

During the present season, three fields have been under experimentation with sulphur for the soil rot. Two of them have been in duplicate, located upon the adjoining farms of Mr. George W. Jessup and Mr. William Schmierer, Cinnaminson, N. J. The plan of the experiment was to apply sulphur in the row before setting the plants, in amounts ranging from 50 pounds to as high as 400 pounds per acre. The plots were four rows wide and sixteen rods long, each plot representing one-tenth of an acre.

The following are the results obtained upon the Jessup field :

	Clean Roots.	Marked Roots.
Sulphur, 50 pounds per acre	150	475
Check.....	375	375
Sulphur, 100 pounds per acre	750	256
Check.....	925	206
Sulphur, 200 pounds per acre.....	1,000	75
Check.....	975	137
Sulphur, 400 pounds per acre.....	1,075	50

The Schmierer field gave the following results :

	Clean Roots.	Marked Roots.
Sulphur, 50 pounds per acre.....	475	375
Check.....	325	375
Sulphur, 100 pounds per acre.....	425	475
Check.....	325	375
Sulphur, 200 pounds per acre.....	325	475
Check.....	225	375
Sulphur, 400 pounds per acre.....	525	300

Putting the two together the following figures are obtained :

	Clean Roots.	Marked Roots.
Sulphur, 50 pounds per acre.....	625	850
Check.....	700	750
Sulphur, 100 pounds per acre.....	1,175	731
Check.....	1,250	581
Sulphur, 200 pounds per acre.....	1,325	550
Check.....	1,200	512
Sulphur, 400 pounds per acre.....	1,600	350

A study of this last set of figures leads to the conclusion that the yield of clean roots increases with the increase of the amount of sulphur, namely, 625, 1,175, 1,325 and 1,600 pounds; on the other hand, the decrease of marked roots is constantly and uniformly in the same direction, namely, from 850, 731, 550 to 350 pounds.

In the plot experiments of two years' standing, previously described, the amount of sulphur did not fall in the lowest amount below 625 pounds per acre, and this supplemental test brings the amounts down through 400, 200 and 100 to 50 pounds. It would seem that the most profitable amount to use is between 200 and 400 pounds, or, in round numbers, 300 pounds.

In the present experiments the sulphur was placed in a fertilizer machine and scattered in the open row. The farmers in this neighborhood bought the sulphur in large quantities, fully 50 barrels, and it was procured for about \$20 a ton or not far from a cent a pound. At that rate the cost of the sulphur, 300 pounds, and its application could not exceed \$4 per acre. Taking the average of the three checks, 1,050 pounds, it gives 550 pounds of clean roots in favor of the plots receiving the 400 pounds of sulphur per acre, or 2,750 pounds for the whole acre. This is 110 baskets, counting 25 pounds to the basket, which at 25 cents a basket gives a net profit for the sulphur of \$23.50 per acre, and when the price is 60 cents a basket, a profit of \$62 per acre.

Another experiment was carried out upon the farm of Mr. Elmer Bradshaw, Mickleton, N. J., where the area was half that of the two above tests. The sulphur was mixed with a few times its own bulk of soil, and a small quantity thrown in the hole where the plant was to be set. The amounts per acre were the same as in the other experiments and the results were as follows :



Fig. 25.
Portion of plant showing the Stem Rot of Sweet Potatoes.

	Clean Roots.	Marked Roots.
Sulphur, 50 pounds per acre.....	25	81
Check.....	4	110
Sulphur, 100 pounds per acre.....	23	90
Check	5	85
Sulphur, 200 pounds per acre	20	70
Check	6	57
Sulphur, 400 pounds per acre.. ..	34	16

Here, while the yield was not large and the soil rot very bad, it is seen that all three checks did not together yield as many clean roots as any one of the treated plots. With so small a crop it is not easy to show that sulphur would pay, but there is unmistakable evidences of its wholesome effect shown in the table. If the marked roots are considered equal to two-thirds their weight of clean ones, the ratio between the average of the two plots receiving the largest amounts of sulphur and their separating check plot would be as 41 to 25. Had the crop here been equal to that of the other two experiments, the difference between the check and its adjoining treated plots would have been 125 baskets, or about \$31 at 25 cents per basket—a net gain of \$26 per acre for the sulphur.

In dollars and cents the experiments of the present season show a gain for sulphur of from \$23.50 to \$26 with potatoes selling at 25 cents a basket and an average of \$50 if the selling price is 50 cents per basket.

The Stem Rot of Sweet Potatoes.

There has been more than a usual amount of the stem rot of the sweet potatoes, and Figure 25 is here introduced that growers may be aided in recognizing the trouble. This disease is due to a fungus that attacks the stem near the surface of the ground, causing it to decay. The vine is killed, and if the plant has made roots of some little size they may send up new shoots, but they do not amount to anything. The engraving shows an instance where the main stem has been girdled, but the secondary roots from the stems lying upon the ground have grown to some size and the vine still continues to live, but without any satisfactory results. No experiments with fungicides have been made and no remedy is suggested.

Sweet Potatoes Upon the Experiment Area.

A belt of four rows of sweet potatoes was grown alongside of Series VI. and between it and the ornamental grounds. A white, a yellow and a red variety were grown, with a view of testing this crop upon the soil of the experiment area, and noting any differences that might arise in the amounts of fungous enemies. The soil proved favorable for a rank growth of vines, but the roots were very inferior in shape and quality. None of the serious troubles, as black rot or soil rot, made their appearance, while the mildew appeared to some extent upon the foliage, and was in a measure controlled by all of the four fungicides employed. There were some differences in the yields, as the following figures show: White, 141.5 pounds; red, 202.5 pounds; yellow, 200.5 pounds.

EXPERIMENTS WITH BEANS.

During the two previous years (1894-95) Golden Wax beans have been grown, two crops each season, upon Plot I., Series V., of the experiment area. The same variety and two crops have been again raised upon the same land this season, thus making a total of six crops of the same kind upon the plot. The two enemies under consideration have been the anthracnose, or "Pod spot," due to the fungus *Colletotrichum legearium* Pass. and the bacterial blight.

For the convenience of the reader the summary for the two previous seasons given in the report for last year is here reproduced in part.*

Summary for the Past Two Years.

The soaking in Bordeaux mixture of beans before sowing the seed does not check the development of anthracnose in the crop. Cupram in 1894 was found nearly equal to Bordeaux. In 1895 cupram was less effective.

Eau Celeste gave good results, followed closely by the "hydrate." Sulphate of copper used with soap, to cause the substance to adhere, gave results practically identical with the check belts, and when used

* A full consideration of the details upon which the summary is founded is given in the report for 1894, pages 294-300, and for 1895, pages 283-292, with engravings of diseases and plates showing some of the results.

without the soap, yielded the poorest returns of all substances. Sulphide of potassium, while tested only on a small scale, gave no indications of fungicidal properties with beans.

The third crop upon the same land showed over four times as much pod-spotting as the first crop grown at the same time upon adjoining new land. The total crop was somewhat larger upon the old land.

A test of irrigation with one belt of the second crop of 1895 showed that the yield of pods was more than doubled and the quality much improved. Upon the other hand, the spotted pods were increased fourfold, thus indicating that water in this instance does not act as a fungicide.

When the old spotted pods of a previous crop are placed upon a belt as a mulch, they will communicate the disease to the succeeding crop, the increase over normal belts being fourfold.

Four and a half inches in the row, with the rows twenty inches apart, seems to be the best distance for beans of the Golden Wax type.

The planting of the old bean plot was upon April 25th, and the belt contained the same number of rows (6) as formerly. In the cultural belt different depths of planting were tested in place of different distances of the year before. The following diagram (Figure 26) indicates the treatment for each of the belts:

Belt 1.	2.	3.	4.	5.	6.
Sprayed with soda- bordeaux. Row 6 mulched with excelsior.	Sprayed with Bordeaux. Row 1 mulched with excelsior.	Sprayed with potash- bordeaux. Row 6 mulched with marsh hay.	Check. Row 1 mulched with marsh hay.	Irrigated. Row 6 mulched with fresh hay.	Depths, 2 rows, 6 in. deep. 2 " 4 " 2 " 1 " Pods of previous crop applied to soil in Nov., 1895.

Fig. 26.

Plan of Bean Experiments for 1896.

An adjoining row, each, of the soda bordeaux and the Bordeaux belts, received a mulch of excelsior; in like manner the adjoining row of potash-bordeaux and check received marsh hay, and the corresponding rows in the irrigation and depths belts, fresh meadow hay as a mulch.

	Belt 1.	2.	3.	4.	5.	6.
Pods, sound.....	60.75 lbs.	76.5 lbs.	78 lbs.	67.5 lbs.	60.5 lbs.	41 lbs.
Pods, bacterial.....	6 pods.	13 pods.	8 pods.	4.5 "	2.5 "	.5 "
Pods, anthracnose.....	0 "	0 "	0 "	6.5 "	14.5 "	8.75 "
Total	61 lbs.	77 lbs.	78.25 lbs.	78.5 "	77.5 "	50.25 "
Tops	62.5 "	77.5 "	71.5 "	87.5 "	101 "	67 "
Grand total.....	123.5 "	154.5 "	144.75 "	166 "	178.5 "	117.25 "

Fig. 27.

Results of Bean Experiments upon Plot I., Series V., for First Crop in 1896.

It is seen that the anthracnose is absent from the sprayed belts, but is in considerable abundance elsewhere, the largest amount being in the irrigated belt, where the percentage was 18.70 and 8.28 per cent. in the check. This test illustrates the comparatively equal value of the three fungicides employed, and the effect of the irrigation, which more than doubled the amount of the pod spot above that of the check.

In the cultural belt, the 50 per cent. increase of anthracnose over that of the check is to be set down to the undesirable effect of the old pods and refuse of the plot that were purposely placed upon this belt at the close of the harvest of the preceding crop.

The bacterial blight was almost absent from the sprayed belts, but showed itself to some extent in the check, 5.73 per cent., and less in the irrigated belt.

A glance at the total weights of the crop shows that the irrigated belt led, followed closely by the check, that was doubtless favored by its adjoining the watered belt. That the cultural belt was not equally affected will be apparent when the depths are studied in detail. Of the three sprayed belts, the Bordeaux gave the largest yield of both pods and tops, followed by the one receiving the potash-bordeaux.

One row in each belt was mulched, but not with the same material, and therefore the results are not comparable throughout. The results are given under the general heading of "Experiments with Mulch."

In the cultural belt the beans were planted as follows: Two rows, six inches; two rows four, and two rows, one inch deep. The results are given in the table below, brought to the terms of a whole belt for each:

Beans Planted.	6 Inches.	4 Inches.	1 Inch.
Pods.....	27.6 pounds.	45 pounds.	105.9 pounds.
Tops ..	30 "	60 "	105 "
Total.....	75.6 pounds.	105 pounds.	210.9 pounds.

Anything below one inch proved unwise, and the latter was better than an average of all the other belts in the plot, where the depth was two inches. The five belts at the normal depth gave an average of 155.9 pounds, while the one-inch-deep rows gave a yield per belt of 210.9, an increase of 73 per cent. There is a suggestion here that two inches is deeper than is best for planting beans, and somewhere between it and one inch may be better.

The Second Bean Crop for 1896.

A second crop of beans was planted upon the old bean land, Plot I., Series V., on July 17th, and was in all respects a duplicate of the first, except that mulching was omitted between the irrigated and the cultural belts. The following results were obtained at the harvest on September 25th :

	Belt 1.	2.	3.	4.	5.	6.
Pods, sound.....	35.5 lbs.	40.5 lbs.	44 lbs.	30.5 lbs.	34.5 lbs.	25 lbs.
Pods, bacterial.....	2.4 "	2.7 "	2.6 "	13.6 "	11 "	7.3 "
Pods, anthracnose....	0 "	1 pod.	2 pods.	4.75 "	9.25 "	2.5 "
Total.....	37.9 "	43.2 lbs.	46.6 lbs.	44.85 "	54.75 "	34.8 "
Tops.....	31 "	31 "	35 "	37.5 "	33.5 "	23 "
Grand total.....	68.9 "	74.2 "	81.6 "	82.35 "	93.25 "	57.8 "

Fig. 28.

Result of Bean Experiments upon Plot I., Series V., for Second Crop in 1896.

From the list of total weights it is seen that irrigation leads, followed closely by the check. Of the sprayed belts the potash-bordeaux is somewhat better in both pods and tops than the Bordeaux with the soda-bordeaux giving the same amount of tops as the Bordeaux, but a smaller yield of pods.

There was practically no anthracnose in the three sprayed belts, the exact record being two pods for the potash-bordeaux, one for the Bordeaux and none for the soda-bordeaux. A small percentage of the bacterial blight was present, but less in the soda-bordeaux belt than in the other two. The largest amount of disease was with the check, where nearly a third of the pods were spotted and a somewhat less amount appeared upon the beans under irrigation. The cultural belt shows a large amount of bacterial blight, and contained double the quantity of anthracnose found in all the other belts, due probably to the application of the diseased pods of the autumn before.

Beans Upon New Land.

Plot IV., Series III., previously in tomatoes for two years, was sown to beans in exact duplication of the plot above described, the leading thought being the comparison of new land with that having had two crops each for the two previous years.

The following are the results (Figure 29):

	Belt 1.	2.	3.	4.	5.	6.
Pods, sound.....	68 lbs.	74 lbs.	62 lbs.	69 lbs.	49 lbs.	67 lbs.
Pods, bacterial.....	2 pods.	16 pods.	2.5 "	4.5 "	8 "	3 "
Pods, anthracnose.....	0 "	16 "	4 pods.	8.5 "	4 "	2 "
Total.....	64 lbs.	75 lbs.	64.5 lbs.	76 "	56 "	72 "
Tops.....	75 "	80 "	72 "	80 "	72 "	81 "
Grand total.....	148 "	155 "	136.5 "	156 "	128 "	153 "

Fig. 29.

Results of Bean Experiments upon Plot IV., Series III., for First Crop in 1896.

It is seen from the table that the check gave the best returns, a fact that can be explained because of better land and the favorable conditions for moisture alongside of the irrigated belt. It is also possible that the fungicides had some unfavorable effect upon the beans. The irrigation was greatly in excess of the amount required, the purpose being to make a thorough test of water in its influence upon the health of the plants and the development of fungi. It is seen that the anthracnose was met with to a considerable extent, 7.32 per cent., upon the irrigated belt. Less than half, 3 per cent., of the amount was upon the check belt, still less upon the cultural (depths) belt, and upon the sprayed area it was almost entirely absent, sixteen pods showing it upon the bordeauxed belt, two pods upon the potash-bordeauxed belt, and none upon the soda-bordeauxed belt.

The bacterial disease was somewhat abundant, 5.36 per cent., upon the irrigation belt; a trifle less, 4.76 per cent., upon the check belt; still less, 2.79 per cent., upon the cultural belt, and almost none upon the sprayed portion, there being sixteen pods upon the bordeauxed belt, ten upon the potash-bordeauxed belt, and one pod upon the soda-bordeauxed belt.

The results in the cultural belt where depths of planting were tested are, in terms of a whole belt, as follows:

Beans Planted.	6 Inches.	4 Inches.	1 Inch.
Pods.....	51	67.5	91
Tops.....	63	96	84
Total.....	114	163.5	175

This shows that the one-inch depth is superior to the others and by comparison with the five belts in the plot, planted at the depth of two inches, that the yield of the one-inch planting is seen to be considerably above the average of 133.6 pounds, an increase of 76 per cent. This is almost the same increase that was found in the first crop upon the old bean land. In the second crop the rows planted one inch deep received such injury that they cannot be considered. As before stated, beans of the sort used upon the soil in hand may better be planted less than two inches deep.

No second crop of Wax beans was grown upon the new land, but instead, one-half of the rows were permitted to stand and mature their seed for use in the second crop upon the old land.

Three varieties of dwarf limas were sown in each belt, one row in place of each of the three alternate rows that had been harvested green. It was too late for any crop, but they were used for testing fungicides, and the results are given elsewhere under "Fungicides and Spraying."

EXPERIMENTS WITH TOMATOES.

An entire series was devoted to tomatoes in 1894. Six belts were sprayed with Bordeaux and the same number with cupram. The plants throughout the series were so little infested that no results of any importance followed from the use of fungicides. The yield obtained from a belt in which the plants were staked was not only considerably smaller, but the percentage of fruit rot was much greater than in adjoining belts in which the plants were allowed to remain upon the ground.

In 1895 two plots instead of four were assigned to tomatoes, and five of the belts in each plot were treated with fungicides, as indicated in the following table (Figure 30):

Plot III.	Sulphate of copper without soap.	Bordeaux.	Sulphate of copper with soap.	Check.	Eau Celeste without soap.	Potassium sulphide.
Plot IV.	Sulphate of copper with soap.	Bordeaux.	Sulphate of copper without soap.	Check.	Eau Celeste with soap.	Potassium sulphide.

Fig. 30.

Plan of Tomato Experiments for 1896.

There was a considerable increase in the percentage of leaf blight over that of the previous season, but outside of the cultural belt referred to below, none of the belts were seriously infested.

The results of the above experiments were summarized in the report of 1895 as follows:

"Only one fungicide gave any marked effect, namely, Bordeaux, which reduced the decay of fruits to one-half of that upon the check belts. Sulphate of copper and Eau Celeste, both with and without soap, were worthless, and no favorable results came from the use of sulphide of potassium. Pruning the vines to a single stalk and tying them to a stake greatly shortened the crop, both in amount and period of ripening. Old vines added to the land in the fall stimulated the next crop of tomatoes, but the plants soon became sickly and the fruit comparatively poor. Irrigation late in the season gave no important results."

Experiments in 1896.

Plot III. of Series III. was again devoted to tomatoes in 1896. The plan of the experiments introduced is given in the following table (Figure 31):

Belt 1.	2.	3.	4.	5.	6.
Sprayed with soda-bordeaux. Row 6 mulched with excelsior.	Sprayed with Bordeaux. Row 1 mulched with excelsior.	Sprayed with potash-bordeaux. Row 6 mulched with marsh hay.	Check. Row 1 mulched with marsh hay.	Irrigated. Row 6 mulched with fresh hay.	Tomato plants of previous crop piled upon ground over winter. Row 1 mulched with fresh hay.

Fig. 31.

Plan of Tomato Experiments for 1896.

The yield of each of the six belts is given below (Figure 32) in terms of ripe, green and spotted fruits. The green tomatoes were picked after the plants were destroyed by frost.

	Belt 1.	2.	3.	4.	5.	6.
Ripe	1,507	1,512	1,308	1,278	1,087	1,625
Green.	890	800	250	100	250	200
Spotted.....	108	68	108	108	168	119
Total.....	1,943	2,075	1,661	1,486	1,450	1,944

Fig. 32.

Product of the Tomato Belts.

As above indicated, the percentage of spotted fruits was not large in any of the belts, but was somewhat lower in the sprayed than in the three unsprayed belts. As heretofore, the fruit rot was caused by the tomato anthracnose (*Glæosporium phomoides* Sacc.) The foliage of the tomato plants was much more seriously infested by leaf fungi the present season than was that of either of the two preceding crops. Two forms of leaf blight were conspicuous, namely, *Septoria lycopersici* Speg. and *Cladosporium fulvum* Cke., but much more injury was done by the first than by the last-named fungus.

Blighted leaves were found in the unsprayed belts before the fruit had begun to turn, and at the time when the first ripe tomatoes were gathered, July 21st, much of the foliage had been destroyed. The sprayed belts, at the same time, were not sufficiently infested to be at all noticeable, and continued comparatively uninjured by disease up to the time when they were destroyed by frost. The yield of the several belts as presented in Figure 32, while favorable to the fungicides, indicates in but a small degree the actual difference between the sprayed and unsprayed belts. A majority of the fruits from the untreated plants was, as a rule, smaller than were those from the sprayed, and inferior in quality, owing to the fact that the greater part of the foliage of most of the unsprayed plants had been destroyed, and they were thus unable to properly mature their fruits or to shield them from the sun.

Blight was manifest somewhat earlier in the belt upon which the old plants had lain during the winter, but in a short time all three of the unsprayed belts, of which number six was one, seemed to be equally infested by disease. The excessively large quantities of water

added to belt five resulted in materially diminishing the yield of fruits, a large number of which were cracked and worthless. The percentage of fruit rot was considerably higher in this belt, but the injury due to leaf blight was about the same as in the adjoining belts. Mulching served to keep the fruit cleaner, but otherwise was of no practical benefit.

Summary.

Tomatoes have been grown upon the same ground in the experiment area for the past three years. There was a material increase in the percentage of leaf blight in the second crop over that of the first, and a much greater increase in the third crop over that of the second, in consequence of which the fruits of the infested vines were reduced in size and were inferior in quality. The loss due to fruit rot has been unimportant, and has remained about the same for all three crops.

The fungicides, Bordeaux, soda-bordeaux and potash-bordeaux have thus far proved equally efficient as preventives of tomato leaf blight, and the fruits from the belts so treated have been superior in size and in quality to those from the unsprayed areas.

Tomatoes grown upon land upon which old tomato plants have remained during the previous winter are much more subject to attack from leaf fungi.

Irrigation the past season has given only negative results; the yield of the irrigated belt was lower than elsewhere, and a large percentage of the fruits were rendered worthless on account of cracking.

EXPERIMENTS WITH PEPPERS.

In 1895 Plots I. and II. of Series III. were devoted to peppers of the "Bullnose" variety. The experiments with fungicides in this crop were the same as those introduced in the tomato plots, a statement of which is presented in Figure 31. One of the bordeauxed belts was mulched with old hay.

The only form of disease present in this crop was a small percentage of the pepper anthracnose (*Colletotrichum nigrum* E. & Hals.) infesting the fruits, and upon which the various fungicides had no practical effect. A severe drought prevailed during the latter part of summer and autumn, and very striking results were obtained in the one belt

in which irrigation was introduced. The yield was nearly doubled and the fruits were plump and marketable, while those from the un-irrigated plants were shriveled and undersized.

The product from the belt mulched and sprayed with Bordeaux was somewhat larger and of better quality than that from the un-mulched bordeauxed belt.

Experiments in 1896.

Upon Plot I. of Series III. peppers were again grown in 1896. The plan of the experiments with the fungicides and mulches the present season was a duplicate of that introduced in the tomato plot and stated in Figure 31. The pepper plants and fruits of the previous crop were placed upon belt six in November, 1895, and the fruits were worked into the soil the following spring.

The small percentage of spotted fruits throughout the plot was somewhat larger than in the previous crop, and was alike uniform upon the sprayed and unsprayed belts. There was an abundance of rain throughout the season, and irrigation and mulching were therefore superfluous. The foliage of the plants so treated was noticeably of a lighter green than was that of the unmulched and unirrigated plants; but such treatment did not noticeably increase or diminish the yield. The belt to which the old plants and fruits were applied gave a larger yield of fruits than the average, but was no more infested by disease.

Summary.

The only fungus to be combated in the pepper crops of the past two seasons has been the fruit anthracnose, and upon this the fungicides have had no apparent effect. Irrigation in the dry season of 1895 greatly increased the yield of fruit and improved its quality. No results were obtained from irrigation during the present season. Mulching in a dry season seemed to be of some benefit, but was useless during a season of average rainfall.

EXPERIMENTS WITH EGG-PLANTS.

In 1895 two plots (Nos. III. and IV., Series IV.) were devoted to egg-plants of the variety known as the New York Improved. The chief purpose of the experiment was to prevent, if possible by the use

of fungicides, the common egg-plant leaf spot and fruit rot caused by the fungus *Phyllosticta hortorum* Speg. The plan of the experiments was as outlined in the following table :

Plot III.	Sulphate of copper without soap.	Bordeaux. Mulched.	Sulphate of copper with soap.	Check.	Eau Celeste without soap.	Potassium sulphide.
Plot IV.	Sulphate of copper with soap.	Bordeaux.	Sulphate of copper without soap.	Check.	Eau Celeste with soap.	Potassium sulphide.

Fig. 33.

Plan of Egg-plant Experiments for 1895.

Eight applications of the several fungicides were made at intervals of about ten days. The product of each belt, in terms of sound and decayed fruits, is given below :

Plot III.....	Sound	15	75	17	10	24	6
	Decayed	30	28	35	44	38	40
	Total	45	103	52	54	62	46
Plot IV.....	Sound	14	45	20	31	15	9
	Decayed	46	49	64	33	25	77
	Total	60	94	84	64	40	86

In the following table is indicated the percentage of decayed fruits in each belt :

Plot III.....	66.66	27.18	67.30	81.48	61.28	86.95
Plot IV.....	76.66	52.12	76.19	51.56	62.50	89.53

As summarized in the report for 1895 the results of the season's experiments with egg-plants were as follows :

"The leaf spot and fruit rot of the egg-plant can be materially checked with fungicides. Of the several that were used, Bordeaux only, gave satisfactory results.

"Eau Celeste seemed to have no effect, while sulphate of copper, either with or without soap, gave poorer returns than the belts where nothing was applied.

"Sulphide of potassium failed entirely, and the belts receiving it were remarkable for the large per cent. of decay.

"Mulching egg-plants proved successful, in that the belt receiving a covering of old hay gave not only the largest yield of all, but far less of the decay than elsewhere."

In 1896 but one plot (No. III. of Series IV.) was assigned to egg-plants, and this plot was one of the two upon which egg-plants had been grown the previous year.

The plan of the experiments with the crop, as outlined in the following table, was the same as that introduced in the tomato and pepper plots :

Belt 1.	2.	3.	4.	5.	6.
Sprayed with soda-bordeaux. Row 6 mulched with excelsior.	Sprayed with Bordeaux. Row 1 mulched with excelsior.	Sprayed with potash-bordeaux. Row 6 mulched with marsh hay.	Check. Row 1 mulched with marsh hay.	Irrigated. Row 6 mulched with fresh hay.	Plants and fruits of previous crop piled upon ground over winter. Row 1 mulched with fresh hay.

Fig. 34.

Plan of Egg-plant Experiments for 1896.

Each of the three sprayed belts received fourteen applications of its particular fungicide at intervals of about ten days. The first application was made May 25th, and the last September 30th.

Under the head of "Irrigation of Garden Crops" and "Mulching of Garden Crops" will be found a statement of the outcome of the experiments conducted along those lines in connection with egg-plants.

The conditions prevailing during the past summer, namely, abundant rain and extreme heat, were alike favorable to the egg-plants and to the fungi preying upon them. For the first three or four weeks after the fruit began to develop, the sprayed belts were noticeably freer from disease than the unsprayed, but before much of the fruit had attained a marketable size the product of the sprayed belts was seen to be infested to essentially the same degree as the unsprayed. The presence of the fungus was first manifest upon the leaves, and later upon the calyx or stem-end of the fruit, from which it soon spread to the fruit itself. Not more than one-third of the fruits, whether in sprayed or unsprayed belts, attained a marketable size.

Several plants in each belt were destroyed this season by a stem disease, occasionally observed in the crop of 1895. This malady seemed unaffected by any of the fungicides.

In belt 6, upon which the old plants and fruits of last year were piled over winter, the percentage of fruit rot was very much higher than elsewhere; in fact, but two fruits in the entire belt attained a marketable size. A larger number of plants were also destroyed by the stem disease in this belt than in any of the other belts.

Summary.

The experiments with egg-plants for the past two seasons indicate that when this crop is grown upon land not recently devoted to that crop, the percentage of fruit rot may be largely prevented, as it was in 1895, by treating the plants with the Bordeaux mixture. When grown under the above conditions, good results may likewise be expected to follow from the use of soda-bordeaux and potash-bordeaux.

The growing of two successive crops of egg-plants upon the same land is believed to be inadvisable, since the fungous diseases peculiar to this crop seem likely to accumulate to such an extent as to be beyond the preventive power of fungicides unless applied with greater frequency than may be practicable.

EXPERIMENTS WITH CUCUMBERS.

In 1895 a well-known variety of cucumber, "White Spine," was grown upon Plots III. and IV. of Series V. The treatment of the vines in the several belts is indicated in the following table:

Plot III.	Sulphate of copper without soap.	Bordeaux. Mulched.	Sulphate of copper with soap.	Check.	Eau Celeste without soap.	Potassium sulphide.
Plot IV.	Sulphate of copper with soap.	Bordeaux.	Sulphate of copper without soap.	Check.	Eau Celeste with soap.	Potassium sulphide.

Fig. 35.

Plan of Cucumber Experiments for 1895.

The cucumber crop is usually more or less injured by two forms of fungus disease, the one a mildew (*Plasmopora Cubensis* B. & C.) infesting the foliage, and the other an anthracnose (*Colletotrichum lagenarium* Pass.), which attacks both foliage and fruit. Each of the

diseases was sufficiently abundant in the check belts, and in some of the sprayed belts, to materially reduce the yield of fruits.

The results of the cucumber experiments of 1895 were summarized as follows :

"Cucumbers may be treated with fungicides for the anthracnose and mildew with reasonable hope of success. Bordeaux was the best substance employed in these experiments, and it not only increased the yield largely, but preserved the fruit from rotting. The bordeauxed plants were noticeably freer from the attack of the cucumber beetle than those in the remaining belts. Sulphate of copper, in a less degree than Bordeaux, gave favorable results in both the above points. Eau Celeste was third-rate as a fungicide, and sulphide of potassium failed to surpass the checks. Mulching is useful in preventing decay of fruits. Pruning the vines shortened the crop, without any compensating gains."

Experiments for 1896.

The present season, Plot III. of Series V. was again planted to cucumbers, and a second plot (IV. of Series IV.), upon which cucumbers had not been grown for at least six years, was also devoted to the same crop.

The plan of the experiments in the cucumber plot of Series V. is indicated in the following table. With the exception of mulching, the same experiments were introduced in the cucumber plot in Series IV.:

Belt 1.	2.	3.	4.	5.	6.
Sprayed with soda-bordeaux. Row 2 mulched with excelsior. Yield. 114 fruits.	Sprayed with Bordeaux. Row 1 mulched with excelsior. Yield. 184 fruits.	Sprayed with potash-bordeaux. Row 2 mulched with marsh hay. Yield. 126 fruits.	Check. Row 1 mulched with marsh hay. Yield. 66 fruits.	Irrigated. Row 2 mulched with fresh hay. Yield. 56 fruits.	Fruits of previous crop worked into soil. Row 1 mulched with fresh hay. Yield. 71 fruits.

Fig. 36.

Plan of Cucumber Experiments for 1896.

There was no difference in the treatment of the two plots, except that one row of plants in belts 5 and 6 of Plot III. of Series V. received a mulch of fresh hay as indicated above.

The striped cucumber beetle, somewhat harmful in 1895, was much more so the present season, and began its attack upon the young plants before they were well out of the ground. The experiment was thus seriously interfered with at the outset, for the number of plants in the several belts was unequal, and although the vacant hills were replanted, the difference remained essentially the same, since the younger plants being preferred to the older ones, were most of them destroyed. Air-slaked lime, usually a repellant of this pest, seemed to have little or no effect in this instance. The unsprayed plants were destroyed earlier in the season than were the sprayed, the beetle evidently being repelled to some extent by the fungicides. But after destroying most of the unsprayed plants, the sprayed were infested as the others had been, and by the middle of July most of the vines in all the belts, whether sprayed or unsprayed, were destroyed.

Under such circumstances it was impossible to make any satisfactory comparisons as to the relative amount of blight in the treated and untreated belts. In Series V., where cucumbers had been grown the preceding season, the leaf blight was more manifest than in the crop upon the new ground in Series IV. So far as observed, the only form of blight present was the anthracnose. The sprayed belts were all of them noticeably blighted, but to a less degree than the checks. There was a manifest difference in favor of the two belts sprayed with potash-bordeaux, while the soda-bordeauxed belts seemed to be infested somewhat less than the two treated with Bordeaux.

Had not the vines been destroyed by insects, it is reasonable to suppose that the differences in the relative amount of blight which were beginning to be manifest in July would have become much more pronounced by the end of the season.

One of the plots, that of Series V., was harvested August 8th. The cucumbers at this time were just beginning to ripen, and nearly all were sound. It will be seen from the table (Figure 36) that the yield from the sprayed belts was more than double that from the unsprayed.

The difference in yield must be attributed chiefly to the greater immunity of the seedling plants in the sprayed belts from insect attack, for, as already stated, the vines were everywhere destroyed before the blight had begun to seriously affect the crop.

Most of the vines of the plot in Series IV. were destroyed by

insects as early in the season as those upon the plot just considered. The fruits, however, were not harvested until a month later than those of Series V., but were allowed to remain upon the ground and ripen. The three fungicides continued to be applied to their respective belts as before.

When harvested, September 9th, the yield, in terms of sound and unsound fruits, was as stated in the following table (Figure 37):

	Belt 1.	2.	3.	4.	5.	6.
Sound	127	60	123	27	14	7
Decayed	40	14	30	35	27	65
Percentage of fruit rot.	23.9	18.9	18.4	56.4	65.8	90.2

Fig. 37.

Results of Cucumber Experiments upon Plot IV., Series IV., for 1896.

The percentage of fruit rot is also given for each of the belts.

The difference in yield in favor of the sprayed belts must be assigned, as in the cucumber plot of Series V., to greater freedom from insect attack, but the very decided decrease in the percentage of diseased fruits in the sprayed belts must be attributed entirely to the fungicides. The proportion of fruit-rot in the belts sprayed with Bordeaux and potash-bordeaux was almost the same, and was about five per cent. lower than in the soda-bordeauxed belt. The fruit rot was due in part to the anthracnose and also to what seemed to be a bacterial decay.

Summary.

Bordeaux, in 1895, greatly increased the yield in the belt to which it was applied, and diminished in like degree the percentage of fruit rot. During the present season the value of the mixture as a leaf fungicide was but imperfectly determined, owing to the early destruction of the vines. Its belt was freer from blight than the checks, but was infested somewhat more than the soda-bordeauxed, and decidedly more so than the potash-bordeauxed belt. During both seasons Bordeaux has greatly lessened the percentage of fruit rot.

Soda-bordeaux was used in 1896 for the first time as a preventive of cucumber diseases, and seemed somewhat more effective as a preventive of leaf blight than Bordeaux, and less efficient than potash-

bordeaux. The percentage of fruit rot in the belt so treated was about five per cent. higher than in either of the other two sprayed belts.

Potash-bordeaux was likewise used in cucumber experiments for the first time in 1896. Up to the time the crop was destroyed by insects the vines treated with this mixture were noticeably freer from leaf blight than those sprayed with either of the other two fungicides. The percentage of fruit rot in the potash belt was practically the same as in the one sprayed with Bordeaux.

The experiments of 1896 demonstrate that none of the fungicides employed can be relied upon to protect cucumber vines from the attacks of the striped beetle, although when so treated such vines are much less subject to attack than are adjacent unsprayed ones.

EXPERIMENTS WITH CELERY.

Plots I. and II. of Series IV. were planted with "New Rose" celery in 1895.

Each belt contained two rows of plants; every alternate row was irrigated from the time the crop was set out until about the first of November. The results obtained were summarized in the report for 1895 as follows:

"While there was no large amount of blight, the experiments show that the Bordeaux belts gave both the largest yield of crop and the least percentage of destruction by the fungus. 'Hydrate' came next, followed by cupram.

"The non-irrigated row in each belt showed a larger percentage of blight than the watered one.

"Irrigation gave satisfactory results, it, in round numbers, increasing the marketable crop in pounds threefold, and the value about eight times."

Experiments for 1896.

Another variety of celery, "Boston Market," was grown in 1896 upon Plot IV. of Series VI. It is probable that celery had never been grown upon this spot, certainly not within the last seven or eight years. The plants in belts 1, 2 and 3 were sprayed with soda-bordeaux, Bordeaux and potash-bordeaux respectively. Belts 4, 5 and 6 were unsprayed. Each belt contained two double rows, and it

was proposed to sub-irrigate, by means of loosely-laid tiles, the second row in each of the first three belts, and to surface-irrigate the second rows in the last three belts. Irrigation was begun, but discontinued shortly after, since more than the required amount of moisture was supplied by frequent rains. The plants in all the belts were almost wholly free from blight, and no results were, therefore, obtained from spraying. The crop is upon the ground at the time of writing.

EXPERIMENTS WITH PEAS.

Experiments with the diseases of peas, particularly the leaf blight (*Ascochyta Pisi* Lib.) and the pea mildew (*Erysiphe Martii* Lev.), were not undertaken until the present season, when one plot (IV. of Series V.) was sown to a quick-growing sort—the “First of All.” The first crop was not sprayed, the hope being that the fungous diseases might accumulate upon the plot so that in the future there would be ample opportunity for using fungicides. One of the six belts was irrigated, and in another the depths of sowing varied from the normal. There was so small an amount of blight that no account was made of it. The crop was left upon the vines until the average pods were about midway between the plump green and the mature condition, when the vines were pulled and the pods removed. The following is the table of results for each of the belts:

	Belt 1.	2.	3.	4.	Irrigated. 5.	Depths. 6.
Pods	30.5	26	23.5	33	45.5	25
Vines	18.5	13	8.5	13	33.5	18.5
Totals	49	39	32	46	79	43.5

From this it is seen that there were large gains for the irrigated belt, arising from the fact that there was a dry spell when the plants first started into growth. The results for the rows with different depths of sowing are given elsewhere under the general title of “Depths of Planting.”

The plot was again sowed to peas upon June 27th, the same variety being used, and from the package that was purchased for the first sowing. Two of the six rows in each of the belts were sown with seed from the first crop, that the old and fresh seed might be compared. In addition to this, soil applications were made of sulphur, corrosive sublimate, carbonate of lime and copper sulphate to half belts, with

the hope of checking the disease that comes upon the stems of peas close to the ground. Irrigation was continued upon belt 5 and different methods of sowing were employed upon belt 6, namely, two rows were sown 4 inches deep, two 2 inches deep and hilled up 2 inches, and the remaining two hilled up 4 inches. In harvesting this crop, a small one, the weights of the pods and vines were kept together, and as yet no account was taken of any slight differences in the blight. The figures are given in terms of whole belts :

	Sulphur.	Corrosive Sub.	Carb. Lime.	Copper Sulphate.	Check.	Irrigation.	Depths.
Weight of pods and vines..	11	14.6	19.4	11	14.2	18	12.7
Old seeds.....	6.2	10.3	19.3	20.5	20.8	13.2	13.6
Fresh seeds..	18.2	21.2	20	19.4	19	15	19

It will be seen that the largest yield is with carbonate of lime, and the least with sulphur and copper sulphate. The fresh seeds averaged much better than the old seeds.

The third crop is still upon the ground at time of writing, and shows excellent effects for Bordeaux in keeping off the diseases of the late crops of peas.

EXPERIMENTS WITH BEETS.

The one-fifth acre devoted to beets in 1896 had been a part of a field upon which two successive crops of mangel-wurzels had been grown in 1894 and 1895. The same variety, "Colossal Long Red," was again sown the present season. The primary experiment in connection with this crop consisted in spraying the foliage with the four fungicides described under "Fungicides and Spraying," to prevent the development of the common beet leaf blight, *Cercospora beticola* Sacc. Figure 38 shows the appearance of a beet leaf that is badly infested with the *Cercospora*. This fungus materially injured the two preceding crops, and its re-appearance could be expected with some degree of certainty.

The field was divided into six plots, the first of which was sprayed with soda-bordeaux, while the second was untreated. Plots III. and IV. were sprayed with Bordeaux and potash-bordeaux respectively, while V. was untreated, and to VI. was applied the ammonia-bordeaux. The date of the first spraying was June 6th, when the beet seedlings were about one month old, and the crop was sprayed twelve

times, the last application being made September 14th. The intervals between sprayings ranged from six to fourteen days, the time varying according to the amount of rainfall. Heavy and frequent rains, with high temperatures, prevailed during June and July, and greatly favored the development of the leaf spot. At the same time the above conditions tested thoroughly the fungicidal properties of the several solutions employed, the efficiency of which must have been materially diminished by the washing of the rains.

Little or no blighting was observed during the first four or five weeks after the appearance of the young plants, but from that time, however, the characteristic discolorations began to be noticeable and the disease made rapid progress everywhere except in the sprayed plots, which continued comparatively uninfested. By July 1st there was a decided contrast between sprayed and unsprayed plots, and the difference became more pronounced during the following ten

or twelve weeks, that is, up to the first of September. Only a small proportion of the foliage of the sprayed plants was injured by blight, whereas that of the unsprayed was reduced for the most part to the more recently-developed leaves, the older leaves hanging down shriveled and lifeless. A second form of blight (*Phyllosticta* sp.) was occasionally observed during the months of June and July, but later in the season it seemed to have wholly disappeared. Ammonia-

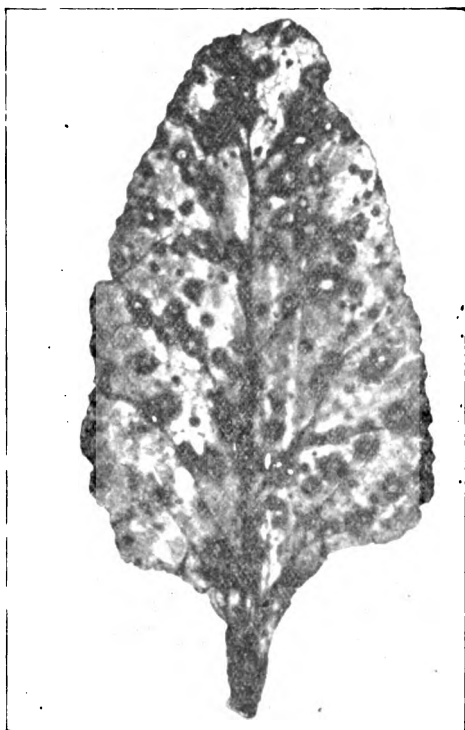


Fig. 38.

Lear badly spotted with the *Cercospora beticola* Sacc.

bordeaux, unlike the other three solutions employed, proved unsatisfactory on account of its caustic action upon the foliage. It was seen after the first spraying that the leaves to which it was applied were burned, but a modification of the formula made the later applications less objectionable.

Had the crop been harvested during the latter part of August it is quite probable that the difference in weight between the sprayed belts and checks might have been greater than was the case a month or so later. To the eye at least the contrast at the earlier date was a most striking one; even the plot sprayed with ammonia-bordeaux seemed to contain a greater quantity of foliage than did its adjoining check. In September the plants grew much more rapidly than during any of the preceding warmer months, while the development of the blight seemed to be materially retarded. By October, therefore, the check plots presented a considerably better appearance than a few weeks previous. The striking difference between the sprayed and untreated foliage is shown in Figure 39, reproduced from Bulletin 107.* This engraving was made from a photograph of the foliage of two beet plants, namely, the poorest of the sprayed ones shown above the tape line, and that of the worst untreated one, below the line.

The crop was harvested October 5th. The yield in weights of foliage and roots is presented below in tabular form (Figure 40).

	FUNGICIDE USED					
	Soda-Bordeaux.	Check.	Bordeaux.	Potash-Bordeaux.	Check.	Ammonia-Bordeaux.
Weight of tops.....	240.5	175	348	388	217.5	278.5
Weight of roots.....	1,135	987.5	1,640	1,849	1,253.5	1,078
Total.....	1,375.5	1,162.5	1,988	2,237	1,471	1,356.5

Fig. 40.

Results with Fungicides upon Beets.

The land inclined gradually and the soil increased in fertility from the upper side (Plot I.) to the lowermost plot.

The weights of foliage and roots produced upon the several plots show that Plot I., sprayed with soda-bordeaux, when compared with its adjoining check, gives an increase in the amount of foliage of 37.5 per cent. and in roots of 15 per cent. Here the sprayed plot occupied somewhat poorer soil than did the unsprayed.

*"Some Fungous Diseases of Beets," January, 1895.

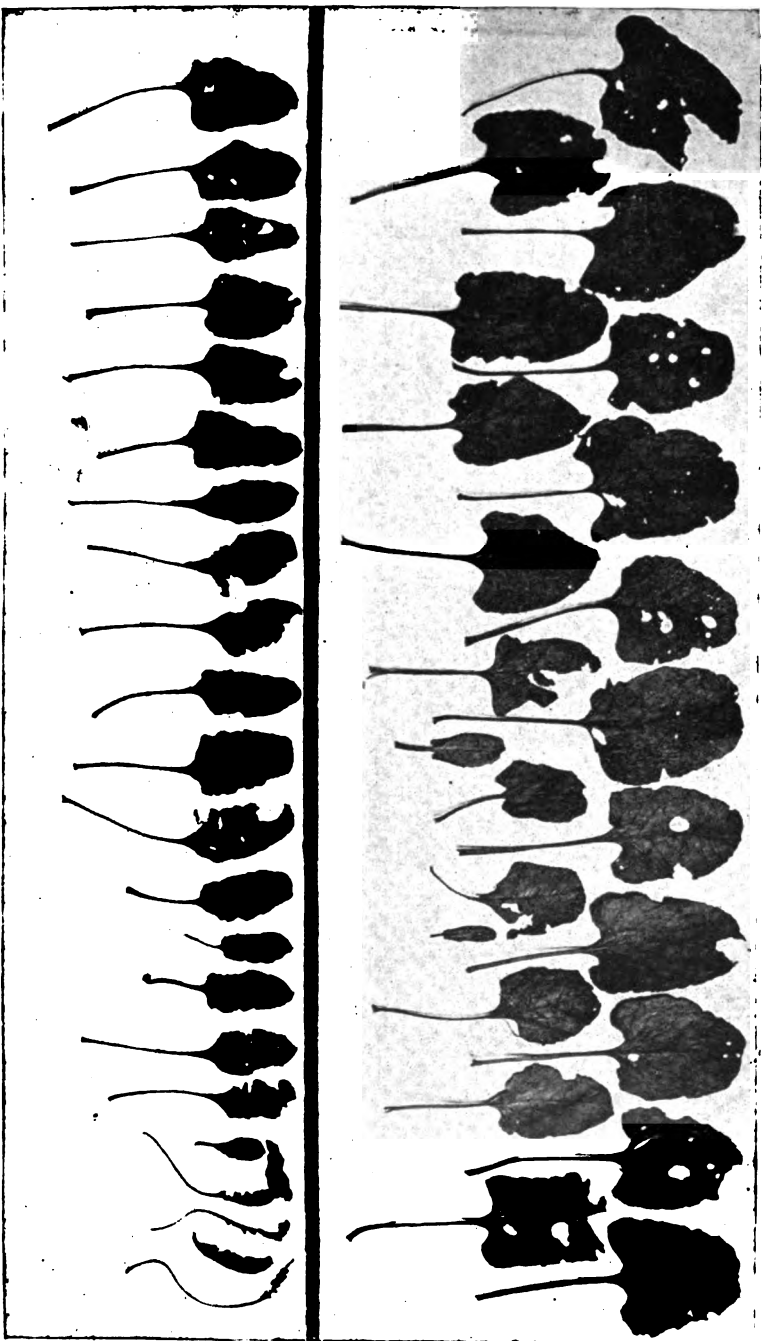


Fig. 39.

The whole complement of leaves from a sprayed and unsprayed Beet Plant.

Plot III., sprayed with Bordeaux, compared with the same check, shows an increase of 98 per cent. and in the amount of roots of 66 per cent. In this instance the advantage from soil fertility is somewhat in favor of the sprayed plot, but when it is compared with the second check, Plot V., the reverse is true. The difference in yield, although less than with the first check, is yet decidedly in favor of the lime plot, the amount of foliage being greater by 60.5 per cent., with an increase in roots of 31 per cent. Compared with the average of the two checks, the Bordeaux plot shows an increase of 77.5 per cent. in amount of foliage and 46.5 per cent. in roots.

Still more favorable results followed the application of potash-bordeaux in Plot IV. Here the increase in foliage over the adjoining check, Plot V., was in foliage 78.5 per cent, and in roots 47.5 per cent. The difference as to soil fertility was in favor of the check. Compared with the yield in the first check the per cent. of increase is considerably greater than in case of the Bordeaux plot. The weight of foliage was more than double that of the check, 121.5 per cent., while the roots showed an increase of 87 per cent. The gain of the potash belt over the average of the two checks was, for foliage 97.5 per cent. and for roots 65 per cent.

In Plot VI., sprayed with ammonia-bordeaux, there was a gain in foliage over the adjoining check of 28.5 per cent., but the weight of roots was less by 14 per cent.

As already stated, this plot occupied the most fertile soil in the series, but owing to the foliage having been greatly injured by the burning of the fungicide, it was only to be expected that the product would be much below the normal. That the injury was due to the fungicide rather than to the fungus was apparent, since the spotting of the latter was not sufficient to produce any appreciable harm to the plants.

Scab Upon Beets.

In the bulletin upon diseases of beets above referred to, mention is made of the identity of the scab of the potato and beet. In the spring a quantity of scabbed potatoes was placed upon a small portion of the beet ground. At harvest time nearly all of the roots were more or less scabbed, while elsewhere there was but a very small per cent. of the trouble, and the unity of the potato and beet scab was established by field inoculation.

A second method of verification was adopted in that one of the belts of the series upon which thoroughly-scabby potatoes had been grown the previous season was sown to beets of several varieties.

All were badly affected with the scab, there being a larger percentage upon the round than the long sorts. This was due to the fact that the fungus was more active near the surface of the soil than elsewhere. Figure 41, made from a photograph of a long beet, illustrates the fact that the scabs are generally confined to a zone of about three inches, beginning an inch or so below the surface. In no case were any beets in the beet series outside of the area receiving the scabby potatoes so badly scabbed as those that were grown in the land after scabby potatoes. The proof is quite conclusive that the disease is the same in both beet and potato, and the practical point is enforced that one of these diseased crops should not follow the other.

EXPERIMENTS WITH SUNFLOWERS.

A row of sunflowers (*Helianthus annuus* L.) of the ordinary sort, grown for its seed for farm use, was sown alongside of the field of beets. The chief point in the experiment was to make a test of four spraying mixtures for the rust (*Puccinia tanacetii* D. C.), a disease that is abundant upon the sunflowers in the State. The sunflower is also affected with a stem trouble due to a fungus (*Phlyctæna* sp.), closely related to the serious stem blight of the cosmos.

The row of sunflowers received the sprayings according to the plan given below :

Am.-Bordeaux. Check. Potash-Bordeaux. Bordeaux. Check. Soda-Bordeaux.

The rows were 138 feet long and each belt, therefore, twenty-three feet wide, with the plants a foot apart in the row.

There were twelve sprayings, and at the close of the season the results were obtained by selecting the largest five plants in each of the six sections. From these chosen plants the leaves were all divided into the living ones and those that were dead.

	Live Leaves.	Dead Leaves.
Soda-bordeaux.....	71	56
Check	70	55
Bordeaux.....	71	57
Potash-bordeaux.....	27	72
Check.....	40	68
Ammonia-bordeaux	13	82

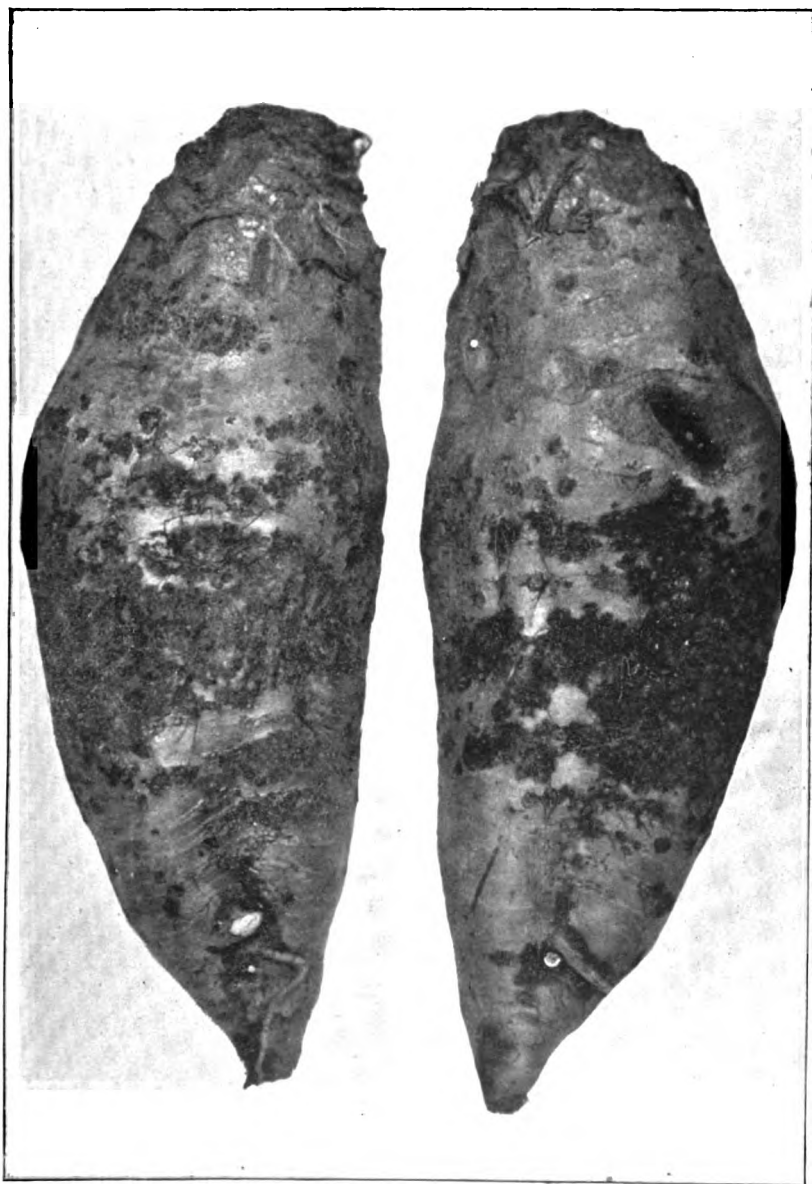


Fig. 41.

A beet illustrating the 'zone' of Scab, midway between top and bottom.



Fig. 48.

A larger view of the Leaf sprayed with the Potash-Bordeaux and a Check.

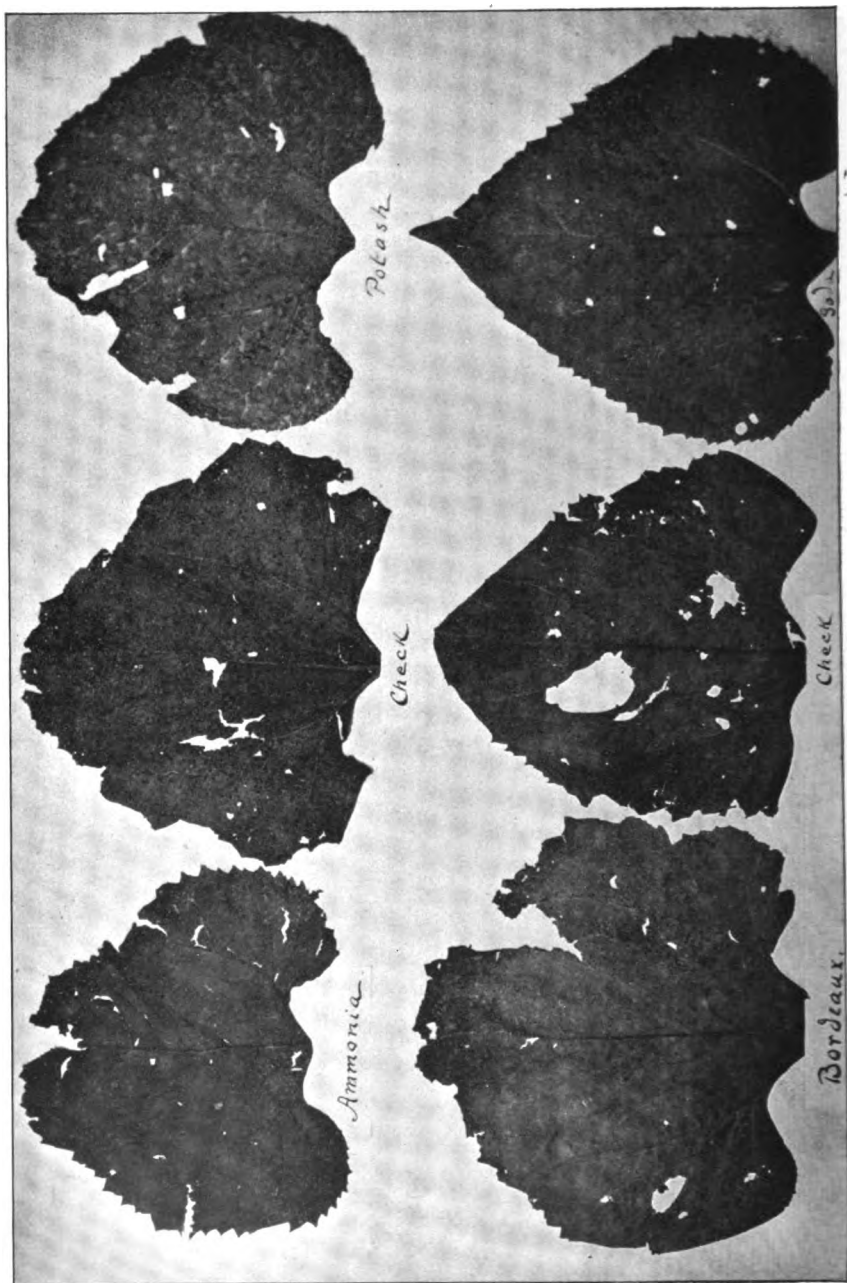


Fig. 42.
Six Sunflower Leaves, showing the effects of the four Fungicides upon the Rust.

This table shows that the ammonia-bordeaux gave the least number of live leaves and the potash-bordeaux next, with two checks occupying a middle position in the scale, and exceeded by the Bordeaux and the soda-bordeaux. These figures, while they give the rate of maturing of the foliage, do not prove to be an index of the amount of rust upon the plants.

To determine the relative rustiness of the foliage the following plan was adopted: The worst five rusty leaves were selected from the five best plants, and from these five the average leaf was taken in each section. Upon these the pustules (sori) of the rust were counted with the following results in terms of pustules per square inch of leaf surface:

	Number of Pustules.
Soda-bordeaux.....	36
Check	213
Bordeaux	25
Potash-bordeaux.....	27
Check	242
Ammonia-bordeaux.....	2

From this table it may be seen that all of the fungicides were active in keeping down the number of spore spots. Upon the leaves receiving the ammonia-bordeaux almost no rust made its appearance, while with the soda-bordeaux the amount was less than a sixth that shown by the average of the checks. There was but a trifle of difference between the results with the Bordeaux and the potash-bordeaux, there being less than an eighth of that shown upon the checks.

No satisfactory results were obtained in the attempt to check the stem blight (*Phlyctana*), and this accounts for the apparent discrepancy between the two tables of results above shown. In short, the stem blight attacked the plants indiscriminately, and thus made serious inroads upon a plant whether it was rusted or not, sometimes breaking it down prematurely.

Figure 42 shows six sunflower leaves with the effects of four fungicides upon the rust. In Figure 43 is given a larger view of a leaf sprayed with the potash-bordeaux along with one from a check section of the experiment row of sunflowers.

EXPERIMENTS WITH ONIONS.

While there is but very little onion smut (*Urocystis cepulae* Fr.) in the State, there have been calls for experiments from some localities. Smutted onions were obtained through the kindness of Dr. Sturges, of the Connecticut Experiment Station, and Professor Seymour, of Harvard University.

In the greenhouse the following scheme was carried out. Three boxes of earth had onion smut spores added to the soil in abundance. One of these boxes in addition had sulphur added at the rate of 1 part to 200 of soil. A second received nothing, while the third had corrosive sublimate mixed with the soil, 1 part to 4,000.

In another set of three boxes the soil was free from smut, but the seed rolled in sulphur and smut spores in one case, untreated in the second and smeared with spores and soaked in corrosive sublimate solution, 1 part to 1,000 for one hour in the third.

The onion plants came up well in all six of the boxes and were afterward transplanted to the open ground. As no smut appeared upon any of the onion plants, there are no results with fungicides to be recorded. It is likely that the spores were already dead before they were employed in the experiment.

EXPERIMENTS WITH CORN SMUT.

A series of experiments in every way similar to that above enumerated for onion smut was carried out with corn smut (*Ustilago maydis* D. C.) and with similar negative results. A variety of popcorn, "White Pearl," was used and the soil, or the grain, as the case may be, was inoculated with spores obtained from ears of common field corn in a neighboring stack of stalks. The experiment was carried through in the greenhouse.

Fungicides and Spraying.

Upon the crops previously considered in this report, experiments have been carried out with fungicides. Four substances have been used as a spray, namely, Bordeaux, soda-bordeaux, potash-bordeaux and ammonia-bordeaux, while several other fungicides have been

added to the soil in various strengths, each of which receives mention in the following pages.

Mr. J. A. Kelsey, as field assistant, has had charge of the work of spraying, much of which was done by Mr. Thos. E. Gravatt, a member of the Senior Class, who spent his three months' vacation upon the experiment area.

EXPERIMENTS WITH BORDEAUX MIXTURE.

Bordeaux as recommended in previous reports from this department, is prepared according to the following formula :

Copper sulphate (bluestone).....	5 pounds.
Quicklime	5 pounds.
Water	50 gallons.

To dissolve the copper sulphate, it should be put in a bag of some coarse material and suspended so as to dip into the water not more than two or three inches. When so suspended many pounds of the substance will dissolve in a few hours without further trouble, while if a like amount be simply dropped into the water the crystals will go at once to the bottom, and unless stirred long and vigorously, except in boiling water, it will require days for all to completely dissolve. One gallon of water to each pound of the bluestone is sufficient. It will be found most convenient, especially when five pounds or more are to be dissolved, to suspend the bluestone in water over night, as above directed. The process of solution may be greatly hastened by the use of hot water, which is often much more convenient when small quantities of Bordeaux are to be prepared at once, but if several hours are allowed, cold water will answer equally well. Only wooden or copper vessels should be used to contain either the copper sulphate solution or the prepared Bordeaux.

To combine the two constituents, copper sulphate and lime, the diluted lime-wash may be poured into the diluted copper solution, or *vice versa*. Before using, the mixture should be thoroughly stirred. It has been found that the Bordeaux mixture remains in suspension much longer if the two constituents are each diluted to one-half or one-fourth the volume of the prepared Bordeaux when ready for use, instead of mixing the two in a more concentrated form and diluting afterwards. For example, if it is desired to make up 50 gallons of Bordeaux, dilute the copper sulphate solution and the milk of lime

each to 25 gallons; the two, when combined, will be ready for use without further addition of water. Instead of diluting the two constituents to 25 gallons each, it may be found more convenient to dilute each to half that quantity, or 12 5 gallons, and after mixing the two add 25 gallons of water.

Prepared according to the above formula, the mixture contains lime greatly in excess of the amount actually required to neutralize the copper sulphate; but for the use of those unfamiliar with the preparation of fungicides, the Bordeaux so prepared possesses the advantage of being absolutely safe.

The spraying at this Station has thus far been done with a five-gallon knapsack pump, which for small areas will be found most convenient. For treating entire fields or for spraying orchards and vineyards a force-pump, attached to a tank mounted on wheels, will be found necessary. Spraying machinery, to suit most requirements, can now be obtained from a number of reliable firms throughout the country.

In the Bordeaux formula employed during the season of 1895, the percentage of lime was somewhat reduced, as shown below:

Copper sulphate	6 pounds.
Quicklime	4 pounds.
Water.....	60 gallons.

During the present season the lime was added not much in excess of the amount actually required to produce an alkaline reaction, and was about half the amount called for in the formula just stated. The proportions were as follows:

Copper sulphate.....	6 pounds.
Quicklime	2 pounds.
Water	60 gallons.

As a fungicide, Bordeaux prepared according to the last-mentioned formula gave as good results as a like number of sprayings with Bordeaux prepared according to the formula employed in 1895. When sprayed upon the foliage, the Bordeaux prepared according to the new formula is not nearly so conspicuous and therefore less objectionable as a fungicide with which to treat ornamental plants.

All danger on account of there being insufficient lime to neutralize the solution may be avoided by testing with a bit of red litmus paper,

only a small supply of which will be necessary for a season's sprayings and can be obtained at any drug store. If the paper when dipped in Bordeaux turns blue, the mixture is alkaline and can be applied to foliage without fear of burning; but should the color of the litmus remain unchanged, more lime should be added until a blue color replaces the red in the test paper.

Bordeaux with Potatoes.

In 1894 it was attempted to prevent potato scab by soaking the seed to be planted in certain belts in different strengths of Bordeaux, and afterward spraying it in the open row with like strengths of that mixture. No results of practical importance followed. Spraying the vines with Bordeaux during the same season was likewise void of results, since the leaf blights common to the potato were almost wholly absent. The crop was seriously injured by a stem blight, upon the development of which the Bordeaux mixture had no apparent effect.

The following season (1895) the seed planted in the cultural belt (6) of Plot II. of Series II. was sprayed in the open row at the rate of 4,320 gallons per acre. Thirty per cent. of the yield from the belt so treated was free from scab, while none but scabbed tubers were obtained from the remaining belts in the same plot.

The vines were considerably injured by leaf blight (*Maurosporium*) except in Plot I., sprayed with Bordeaux. Here there was comparatively little blight, and the vines continued green for about three weeks after those in the remaining plots were dead.

The present season the cultural belt in Plot II. of Series II. was again treated with Bordeaux, as in 1895. That is, the seed in the open row was sprayed, together with the soil about it, with Bordeaux mixture at the rate of 4,320 gallons per acre. Only negative results followed, since it was found at harvest time that the potatoes from the belt so treated were, without exception, badly scabbed.

The vines of the first belt of each plot in Series II. were sprayed eleven times with Bordeaux. Very little leaf blight of any sort was manifest upon the crop, so that no perceptible difference was observed between sprayed and unsprayed belts. The second plot of Series III., IV. and V. were also devoted to potatoes, and the second belt of each plot was sprayed with Bordeaux, but without results, owing to the almost entire absence of any of the fungous

enemies that so frequently infest the foliage of this crop. The potato vines upon a portion of Series VI. were also sprayed with Bordeaux with like negative results.

Bordeaux with Beans.

In 1894 an attempt was made to prevent the development of the well-known pod spot or anthracnose of the bean (*Colletotrichum leganarium* Pass.) by soaking in Bordeaux seed known to be infested with the germs of the disease. No favorable results from this method of treatment were obtained, and it was therefore abandoned.

The spraying of bean plants in 1894 and 1895 gave much more satisfactory results. The percentage of anthracnose and that of the bacterial blight were much lower in the bordeauxed belts than in the checks.

The merits of Bordeaux as a preventive of bean blights had been sufficiently demonstrated by the experiments of 1894 and 1895, and it was used the present season as a standard with which to compare the two trial fungicides, soda-bordeaux and potash-bordeaux. One belt was devoted to each of the three fungicides in each of the two bean plots.

In the first crop the anthracnose was much more prevalent than the bacterial blight, but as will be seen by referring to the tables of results given elsewhere, both forms of disease were confined almost wholly to the unsprayed belts. So far as indicated by the results of the first crop, there was no practical difference in the fungicidal merits of the three mixtures used.

The plot (I. of Series V.) which has been in beans for three years was again planted to the same variety (Golden Wax) July 17th. The beans upon the new land, Plot IV. of Series III., were followed in August by three varieties of lima beans. The order of spraying was the same for both sorts as in case of the preceding crop. Blight was much more prevalent upon the Golden Wax beans than in the spring, and was almost wholly of the bacterial sort, there being only a small percentage of the anthracnose. The percentage of spotted pods in the sprayed belts, though considerably greater than in the same belts for the first crop, was not sufficient to be of practical importance. On the other hand, the total yield of the check belt was lower than that of the sprayed and the percentage of blight was more than five times as great. As in the first crop, the percentage of infested pods was almost the same in each of the sprayed belts.

No results were obtained from spraying in the plot devoted to lima beans, since the crop remained practically uninfested by fungous enemies.

Bordeaux with Tomatoes.

Extensive use was made of Bordeaux as a leaf fungicide in the experiments with tomatoes in 1894, but practically no results were obtained, owing to the almost entire absence of any of the leaf blights that frequently infest this crop.

The crop of 1895 was somewhat, though not seriously, injured by blight, and the belt sprayed with Bordeaux was noticeably freer from disease than were the checks.

The tomato crop of 1896 was the first to be seriously infested by leaf blight since the experiments with tomatoes began. Blight, due chiefly to the fungus *Septoria lycopersica* Speg.,* was noticeable in early summer, and as a result of its ravages the plants in the unsprayed belts were almost defoliated by the end of August.

Bordeaux was one of three fungicides employed and was applied fourteen times, at intervals of about ten days, to the plants of belt 2. As shown in the table of results, on page 334, the yield in this belt was somewhat greater and the percentage of spotted fruits less than in any corresponding area in the plot. Had a record been made of the weights as well as the number of fruits produced upon the several belts, the difference between the product of the sprayed and unsprayed vines could doubtless be made much more evident, for the fruits produced upon the unsprayed belts were noticeably smaller. On account of their being much more exposed to the sun, the tomatoes borne by the unsprayed vines ripened earlier and more rapidly than did those upon the sprayed vines. As might be expected, such tomatoes were inferior in quality to those ripened under normal conditions.

Bordeaux with Peppers.

An unsuccessful attempt was made in 1895 to prevent the fruit rot of peppers (*Colletotrichum nigrum* E. & Hals.) by the use of Bordeaux. Although the percentage of spotted fruits was not large, the bordeauxed belts were as much infested as the checks, and the plants so treated were somewhat injured.

*Two other fungous parasites, *Macrosporium solani* E. & M. and *Cladosporium fulrum* Cke, were also present but to a less extent than the *Septoria*.

Bordeaux was again applied to one belt of peppers the present season. As in 1895, the crop was free from leaf blight, but the percentage of fruit rot was considerably greater than in the preceding crop, and was as abundant in the sprayed belts as in the checks. The bordeauxed plants this year were uninjured, which may have been due to the more favorable season, or to the fact that a smaller amount of lime was used in the preparation of the fungicide.

Bordeaux with Egg-plants.

Very favorable results were obtained in 1895 from the use of Bordeaux as a preventive of the egg-plant leaf blight and fruit rot (*Phyllosticta hortorum* Speg.) The yield of marketable fruits produced upon the belts so treated was more than double that from the untreated belts, the difference being due chiefly to the greater prevalence of fruit rot among the unsprayed plants. In all the belts there were a few plants destroyed by an obscure stem disease, and upon this the Bordeaux had no apparent effect.

In 1896, egg-plants were grown upon the ground occupied by that crop in 1895, and one belt was sprayed fourteen times with Bordeaux at intervals of about ten days. Although the *Phyllosticta* was abundant in the first crop, it was much more so in the second, and seemed to develop almost as rapidly among the sprayed plants as the among the unsprayed. The stem disease observed in the crop of 1895 was much more prevalent the present season, and about one-fifth of the plants were destroyed by it. As in the previous crop, its development was apparently unchecked by the Bordeaux mixture.

It is believed that the fruit rot might have been materially diminished had the Bordeaux been applied at more frequent intervals—as often as once in five days, perhaps, rather than once in ten or twelve.

Bordeaux with Cucumbers.

The two belts of cucumbers sprayed with Bordeaux in 1895 were noticeably freer from the cucumber mildew (*Plasmopara Cubensis* B. & C.) and the anthracnose (*Colletotrichum legumarium* Pass.) than were the surrounding belts. The vines so treated were likewise much less infested by the common cucumber beetle. As a result of the spraying the yield of fruit was largely increased, and, unlike that from the remainder of the belts, was but little infested by fruit rot.

The cucumber fruits in the plot of Series V. were harvested when about half ripe, and were but little decayed. Those in Series IV. were left upon the ground for a time and the sprayings continued. At the end of about four weeks there was found to be a marked difference between the sprayed and unsprayed as to the percentage of fruit rot. Decayed cucumbers were fewer in the bordeaux belt than in the check by nearly 40 per cent.

Two belts of cucumbers were sprayed this season, but the experiments with this and other fungicides were almost void of results as preventives of leaf fungi on account of the unusual prevalence of the cucumber beetle. Not so many of the seedling cucumber plants were destroyed in the sprayed belts by the insect pest as in the unsprayed, but the plants were sufficiently injured by subsequent attacks to cause them to die prematurely.

As shown elsewhere (page 343), the yield of fruit was noticeably greater in the sprayed belts than in the unsprayed. The difference in yield must, however, be attributed chiefly to there having been a better stand of plants in the sprayed belts. Cucumber blight, chiefly anthracnose, was much more abundant upon this year's crop than upon that of last season, but the vines were destroyed by the beetle before the blight had developed sufficiently to affect the yield.

The cucumber fruits of one plot were left upon the ground to ripen, and were sprayed regularly until harvested, at which time the amount of fruit rot was found to be less in the sprayed belt than in the check by almost 40 per cent.

Bordeaux with Celery.

Celery plants sprayed with Bordeaux, in 1895, gave very decided results in favor of the use of that mixture. The yield, by weight, of the belt so treated was greater than that of the check belts by 55.6 per cent. The difference in yield may be said to have been almost wholly due to the greater prevalence of the celery blight (*Ceroospora Apii* Fr.) upon the unsprayed plants.

For the present season, no results followed from the use of Bordeaux, or any of the other fungicides employed in the celery experiments, owing to the fact that the plants, whether sprayed or unsprayed, remained almost wholly free from any form of blight.

Bordeaux with Beets.

One-sixth of the area devoted to beets the present season was sprayed with Bordeaux for the purpose of preventing the common beet leaf blight, *Cercospora beticola* Sacc. It was further desired to compare its fungicidal properties with those of the three other mixtures employed upon the same crop. The plants were sprayed twelve times in all, the first application being made June 6th and the last September 30th.

The blight was manifest in the check belts within one month after the plants appeared, and as the season advanced a large percentage of the older leaves was destroyed. The foliage of the bordeauxed plots was not materially injured, and when harvested showed an increase in weight over the average of the two checks of 77.5 per cent. The root systems of the sprayed plot showed a corresponding increase of 46 5 per cent.

The relative amount of leaf blight noted during the season and the comparative weights of foliage and roots obtained at harvest time would indicate that in this instance Bordeaux as a fungicide is considerably superior to soda-bordeaux. Compared with potash-bordeaux, however, it was found that the per cent. of leaf spot was somewhat greater upon the bordeauxed plot, and after making due allowance for the difference in soil fertility, the yield obtained from the potash plot was somewhat higher.

Bordeaux with Sweet Potatoes.

The mildew (*Oystopus ipomoeae panduratae* Farl.), commonly found upon sweet potato vines, was noticeable in the belt of sweet potatoes spoken of on page 328, and while not sufficiently abundant to be injurious to the crop, was seen to be much more prevalent upon the unsprayed vines than upon those sprayed with Bordeaux.

Bordeaux with Cosmos.

One-sixth of the cosmos plants were sprayed eight times with Bordeaux. Only negative results followed the treatment, since the stem fungus (*Phlyctena* sp.) seemed to develop as rapidly upon the sprayed as upon the unsprayed plants.

Bordeaux with Sunflowers.

One-sixth of a row of sunflowers was sprayed seven times the present season with Bordeaux at intervals of about ten days. The sunflower is particularly subject to two forms of blight—the one a true rust (*Puccinia Tanacetii* D. C.), which attacks the foliage chiefly, while the other (*Phlyctæna* sp.) infests the stem. The last-mentioned disease was not conspicuous until after most of the seed was mature, and so affected the yield but little. It seemed, however, to be as prevalent in the sprayed belts as in the checks. The rust was first observed about the middle of August, and spread much less rapidly in the sprayed belts than in the checks. At the end of the season the bordeauxed plants were much less infested by rust than the unsprayed, but rather more than those sprayed with potash-bordeaux and somewhat less than the ones sprayed with soda-bordeaux.

Bordeaux with Hollyhocks.

Very favorable results were obtained, in 1896, from the use of Bordeaux as a preventive of hollyhock leaf blight. The sprayings were eleven in number, at intervals of about ten days. The unsprayed plants were apparently uninfested until September, when one of the common hollyhock leaf blights (*Ceroospora Althæina* Sacc.) began to develop, and before the close of the season was quite conspicuous. The bordeauxed plants remained practically uninfested.

Bordeaux with Cercis.

In a row containing twenty young cercis trees, four of the number were sprayed throughout the present season with Bordeaux. Sixteen applications were made in all. The fungous disease (*Cercospora cercidicola* Ell.) so destructive to the foliage of the cercis was not in this instance sufficiently abundant upon any of the young trees to be at all harmful. Late in the season the blight began to be somewhat noticeable upon the foliage of the unsprayed plants, but not elsewhere.

Bordeaux with Pæonies.

The present season twelve pæony plants were sprayed sixteen times with Bordeaux at intervals of about ten days. No results were obtained, since the plants throughout the row, whether sprayed or not, remained uninfested by any of the fungous enemies peculiar to pæonies.

Bordeaux with Gladiolus.

The gladiolus plants grown in 1896 were entirely free from blight, and therefore no results were obtained from the use of Bordeaux or any other fungicide.

EXPERIMENTS WITH SODA-BORDEAUX.

In the spraying experiments of 1896, a second fungicide, which has been termed soda-bordeaux, was used to the same extent as the Bordeaux mixture discussed in the preceding pages. The soda-bordeaux differs from the common Bordeaux in that caustic soda (sodium hydrate) is used instead of lime to neutralize the copper sulphate solution.* The mixture was prepared the present season according to the following formula :

Copper sulphate.....	5 pounds.
Caustic soda.....	1.1 pounds.
Water	50 gallons.

Ten pounds of soda will dissolve readily in two gallons of water, and should be kept in closed vessels, other than wood, which may be drawn from as desired. A two-gallon solution of the above will be sufficient alkali with which to prepare 455 gallons of the soda-bordeaux. A somewhat limited use was made of soda and copper sulphate in 1895, and the results obtained were sufficiently favorable to warrant their being given a further trial.

It will be found more convenient to dilute the required portion of the stock soda solution as was recommended in case of the lime used in the preparation of Bordeaux. The amount of soda called for in the above formula is somewhat in excess of the amount actually necessary to neutralize the copper solution. If the specified amount is used, the excess of soda will not injure the foliage to which the soda-bordeaux is applied any more than does an excess of lime in the ordinary Bordeaux. The mixture will be found more satisfactory, however, if only enough soda is added to neutralize the copper. Pour the soda gradually into the copper solution and stir thoroughly. When most of the alkali has been added it is well to test the mixture with red litmus paper, as recommended in the preparation of Bordeaux.

*A similar fungicide was employed last year, under the tentative name of "Hydrate," mentioned upon page 287 of the report for 1895.

As soon as the litmus shows the slightest change in color, from red to blue, the addition of the soda solution should cease.

The one objectionable feature in alkaline soda-bordeaux is, that the precipitate, blue at first, changes in a short time to brown, after which it settles much more quickly than does the neutral mixture. If one is careful to occasionally shake the knapsack pump, or to keep the mixture well stirred, if the receptacle is a barrel or tank, the settlings need not greatly interfere with the fungicide being evenly applied. In a future report or bulletin the full details of compounding this mixture will be given.

Soda-Bordeaux with Potatoes.

The proportion of potatoes sprayed in 1896 with soda-bordeaux was the same as that sprayed with Bordeaux, and a like number of applications were made. The areas sprayed with this mixture consisted of the first belt in each of the four plots of Series II., and the first belt in each of the potato plots in Series III., IV., and V. Each of the belts above designated received eleven applications of the soda-bordeaux at intervals of about ten days. One of the plots in Series VI., devoted to Early Rose potatoes, was sprayed six times with the same fungicide.

The foliage of the unsprayed potatoes was so little injured by blight that no opportunity was afforded for testing the fungicidal properties of soda-bordeaux, or any of the other mixtures employed upon this crop.

Soda-Bordeaux with Beans.

The first belt in the two plots devoted to beans the present season was sprayed with soda-bordeaux. In the first crop, five applications of this fungicide were made to each of these belts. As shown in the table of results on page 331, the pods produced in the first belt of Plot I., Series V., were practically free from blight, while 14 per cent. of those from the check belt were spotted. Between the soda-bordeauxed belt and its check belt in the bean plot of Series IV., there is seen to be essentially the same difference in favor of the sprayed belt. In the first crop the soda-bordeaux seemed to be as efficient a fungicide as either Bordeaux or potash-bordeaux. The bean plot of Series V. was replanted with "Golden Wax" beans, and lima beans followed

the first crop in Series IV. The plants in the first belt in each of the two plots were sprayed seven times with soda-bordeaux. The yield and proportion of spotted pods are given in the table of results on page 332. Compared with the product of the check, that of the belt sprayed with soda-bordeaux produced five pounds more of sound pods and only about one-sixth as many spotted pods. This fungicide again compared favorably with the two employed upon adjoining belts. No results were obtained in the sprayed belt of lima beans, since the plants throughout the plot were almost entirely free from blight.

Soda-Bordeaux with Tomatoes.

Very favorable results were obtained in 1896 from the use of soda-bordeaux as a preventive of tomato blight. The first application was made May 25th, and the sprayings were repeated at intervals of about ten days until early October, when the vines were destroyed by frost. The table of results on page 335 shows a considerable increase in the number of fruits produced in the belt here considered over that produced in the check. The foliage of the belt sprayed with soda-bordeaux, like that of the belt with ordinary Bordeaux, was infested to a much less extent than any of the unsprayed belts, and there was a very marked difference in the size and quality of the fruit, which is not indicated in the table of results. As a fungicide the soda-bordeaux gave in this instance practically as good results as did the standard mixture, Bordeaux.

Soda-Bordeaux with Peppers.

Like Bordeaux, soda-bordeaux had no apparent effect the present season upon the fruit rot of peppers, there being as large a percentage of spotted fruits in the belt sprayed with that mixture as in the unsprayed belts.

Soda-Bordeaux with Egg-plants.

Fourteen applications of soda-bordeaux were made in 1896 to a belt of egg-plants without noticeably lessening the prevalence of egg-plant fruit rot. As stated elsewhere of Bordeaux, that mixture failed likewise, the present season, to check this malady.

Soda-Bordeaux with Cucumbers.

One belt in the cucumber plot of Series V. and one in that of Series IV. were sprayed in 1896 with soda-bordeaux. The cucumber beetle was repelled for the first few weeks by all the fungicides employed, in consequence of which there was a better stand in the sprayed than in the unsprayed belts, and a corresponding increase in the number of fruits produced by the former. The sprayed vines were finally destroyed by the beetles at about the time the leaf blight was beginning to be somewhat conspicuous. The foliage of the checks was seen to be more infested than any of the sprayed belts. Leaf blight was somewhat less conspicuous upon the soda-bordeauxed vines than upon those sprayed with Bordeaux. The fruits in the cucumber plot of Series IV. were left upon the ground, and sprayed for one month after the vines were destroyed. When harvested, the percentage of fruits in the soda-bordeauxed belt was only about two-thirds as great as in the check. It was, however, about five per cent. higher than in the bordeauxed belt.

Soda-Bordeaux with Celery.

In 1895 the "hydrate" was employed as a preventive of celery leaf blight. The percentage of blight was not large in the check belts, but was noticeably greater than in the belt to which the fungicide was applied.

In 1896 there was an almost entire absence of blight from the plot devoted to celery, and no results followed from the application of fungicides.

Soda-Bordeaux with Beets.

The results obtained in 1895 from the use of "hydrate" as a preventive of beet leaf blight were sufficiently favorable to warrant soda being given a further trial.

In 1896, Plot I. of the beet series was sprayed twelve times with soda-bordeaux, and the foliage so treated was much freer from blight than was that of the checks, but was noticeably more infested than were either of the plots sprayed with Bordeaux or potash-bordeaux.

Soda-Bordeaux with Sweet Potatoes.

That portion of the sweet potato belt to which soda-bordeaux was applied was noticeably less infested by the common sweet potato mildew than were the vines in the unsprayed areas.

Soda-Bordeaux with Cosmos.

Eight applications of soda-bordeaux the present season failed, as did a like number of sprayings with Bordeaux, to check the ravages of the cosmos stem blight.

Soda-Bordeaux with Sunflowers.

As a preventive of the sunflower rust, soda-bordeaux was found to be rather less effective than Bordeaux. The soda-bordeauxed plants were, nevertheless, decidedly freer from rust than were those to which nothing was applied, as is shown by the estimate on page 351. The stem blight of the sunflower, which did not seem to be affected by Bordeaux, was likewise unaffected by soda-bordeaux.

Soda-Bordeaux with Hollyhocks.

A portion of a row of hollyhocks was sprayed eleven times with soda-bordeaux during the present season. By the 1st of September the unsprayed plants were conspicuous because of their much-spotted leaves, a condition due to the presence of one of the leaf fungi common to this plant. The hollyhocks sprayed with soda-bordeaux remained practically uninfested, fully as much so as did those to which Bordeaux was applied.

Soda-Bordeaux with Cercis.

The four young trees of cercis sprayed in 1896 with soda-bordeaux showed some good effects for the fungicide.

Soda-Bordeaux with Pæonies and Gladiolus.

No results were obtained from the use of soda-bordeaux in the pæony and gladiolus experiments, since sprayed and unsprayed plants were not attacked by fungous diseases.

EXPERIMENTS WITH POTASH-BORDEAUX.

A third fungicide was used the present season, in which the lime of the common Bordeaux was replaced by caustic potash (potassium hydrate). Copper sulphate, neutralized with this alkali, has been styled potash-bordeaux. It was prepared according to the following formula :

Copper sulphate.....	5 pounds.
Caustic potash.....	3 pounds.
Water.....	50 gallons.

The potash here considered is obtained in bulk, is more or less impure and costs a few cents a pound by the barrel or drum. To bring the hard lumps into solution they may be placed in a kettle of hot water, where they soon become dissolved. Twenty pounds of the caustic potash readily dissolve in five gallons of water and may be kept as a stock solution until desired, in large bottles or a demijohn. A purer form of potash may be obtained in cans, in which case the lid of the can is removed and the can inverted in the kettle, where, with hot water, it is to be brought into solution and stored for use as before stated.

The formula given above will vary somewhat, and when the commercially-pure potash put up in cans is employed it will be well to follow the directions suggested for soda-bordeaux. The red litmus paper will aid in detecting the presence of an excess of the potash. If the test paper turns blue more copper sulphate should be added, but if it remains unchanged potash needs to be added until the test paper shows the slightest tinge of blue, when no more of the alkali should be added.

Like the soda-bordeaux, the potash-bordeaux, if alkaline, changes in color after a time and the precipitate then settles more quickly than before. This change does not take place so soon, however, as in the soda-bordeaux, and if care is exercised not to add an excess of the potash no difficulty need be experienced on this account.

The potash-bordeaux is eventually washed off the foliage and becomes a part of the soil, and, being a desirable plant-food, it thus becomes a valuable fertilizer after having served as one of the constituents of a fungicide.

Potash-Bordeaux with Potatoes.

In 1896 potash-bordeaux was applied, upon the same dates as the other two fungicides employed, to the third belts of all four plots of Series II. and to the third belts of the plots devoted to potatoes in Series III., IV. and V. A portion of the potatoes in Series VI. were sprayed six times with the same mixture. Since the potato vines throughout the experiment area were almost wholly uninfested by leaf blight, no opportunity was afforded for testing the efficiency of the fungicide under consideration.

Potash-Bordeaux with Beans.

Two belts of the first crop of beans were sprayed in 1896 with potash-bordeaux, the number and dates of application of this fungicide being the same as those of Bordeaux and soda-bordeaux. In the potash-bordeauxed belt of Series V. the percentage of spotted pods at harvest time was lower than in either of the other two sprayed belts adjoining; but in the plot of Series IV., the potash-bordeauxed belt, although much less infested than the check, was somewhat more so than the adjoining bordeauxed belt or the soda-bordeauxed belt.

In the second crop of wax beans the potash-bordeauxed belt contained a somewhat smaller proportion of spotted pods than did the bordeauxed belt and only about one-sixth as many as did the check. One belt of lima beans was sprayed with potash-bordeaux, but as already stated, this crop was uninjured by disease, and hence no result followed from the application of fungicides.

Potash-Bordeaux with Tomatoes.

The third belt of tomatoes was sprayed with potash-bordeaux in 1896, with results decidedly favorable to this fungicide. Up to the time when they were destroyed by frost the plants in the belt so treated were not sufficiently infested by tomato leaf blight to interfere with the normal development of the fruits. On the other hand, the plants in the adjoining check were injured to such an extent by disease that a large proportion of the fruits were decidedly inferior, both in size and in quality. The percentage of leaf blight in the potash-bordeauxed belt seemed to be fully as low as in the bordeauxed belt, while the percentage of fruit rot was somewhat higher.

Potash-Bordeaux with Peppers.

About as many spotted fruits developed the present season, in the belt of peppers sprayed with potash-bordeaux, as in the check belt. Like negative results were obtained in this crop from the use of Bordeaux.

Potash-Bordeaux with Egg-plants.

A liberal use of potash-bordeaux (fourteen applications) failed in 1896, as did Bordeaux and soda-bordeaux, to check the development of the fruit rot of egg-plants.

Potash-Bordeaux with Cucumbers.

Until destroyed by insects, the cucumber vines, sprayed with potash-bordeaux, were noticeably less infested by leaf blight than were those in the check belts. In the plot in which the fruits were left upon the ground to ripen, the proportion infested at harvest time by rot was only about one-fourth as great as in the check. As a preventive of cucumber leaf blight and fruit rot, potash-bordeaux gave evidence of being fully as efficient as Bordeaux.

Potash-Bordeaux with Celery.

None of the blights common to celery appeared in the crop upon the experiment area the present season, and therefore no results followed from the application of fungicides.

Potash-Bordeaux with Beets.

The twelve applications of potash-bordeaux to one plot of beets in 1896, resulted even more favorably than did a like number of applications of Bordeaux. The weight of roots produced in the potash-bordeauxed belt was greater than that produced in an adjoining and somewhat more fertile check, by 47.5 per cent. There was an increase in the weight of the foliage of sprayed beets over that of those in the above check, of 78.5 per cent.

Potash-Bordeaux with Sweet Potatoes.

There was noticeably less mildew upon the sweet potato vines sprayed with potash-bordeaux than upon the adjoining unsprayed ones.

Potash-Bordeaux with Cosmos.

The cosmos plants sprayed with potash-bordeaux were to all appearances as thoroughly infested by the stem blight as were the untreated plants.

Potash-Bordeaux with Sunflowers.

A portion of a row of sunflowers was sprayed seven times the present season with potash-bordeaux. From a careful comparison made near the end of the season, it was estimated that there was only about one-eighth as many rust pustules upon the leaves of the sprayed plants as upon those of the checks. The results obtained from the use of potash-bordeaux were slightly better than those which followed from the use of Bordeaux. Like Bordeaux, potash-bordeaux had no appreciable effect upon the sunflower stem blight.

Potash-Bordeaux with Hollyhocks.

As a preventive of hollyhook leaf blight, potash-bordeaux proved as effective as did Bordeaux. The leaves of adjacent unsprayed hollyhocks were considerably blighted.

Potash-Bordeaux with Cercis.

The four cercis trees sprayed with potash-bordeaux remained uninfested by leaf blight throughout the season. The unsprayed were slightly blighted.

Potash-Bordeaux with Pæonies and Gladiolus.

Since the unsprayed pæonies and gladiolus were not attacked by disease the present season, no results were obtained from the use of potash-bordeaux.

EXPERIMENTS WITH AMMONIA-BORDEAUX.

A fourth fungicide, termed ammonia-bordeaux, was given a comparative trial with the three already considered. It was made up in the following proportions:

Copper sulphate.....	5 pounds.
Ammonia.....	5 pints.
Water.. ..	50 gallons.

The formula for ammonia-bordeaux, as above stated, differs from that for the fungicide known as Eau Celeste, in that the former calls for one-third less ammonia than the latter.*

In the ammonia-bordeaux it was desired to add only sufficient ammonia to produce an alkaline reaction. In preparing a given quantity of ammonia-bordeaux, the alkali should be diluted as recommended in case of lime, soda and potash. For example, if ten gallons of the mixture are to be prepared, the one pint of ammonia should be diluted to five gallons and thoroughly stirred into the copper sulphate solution.

As prepared at first, the mixture contained ammonia in excess of the quantity called for in the above formula, and as a consequence the foliage was greatly injured by burning. Later, the proportion of ammonia used was barely sufficient to produce an alkaline reaction, and the injury from burning was greatly diminished, but the foliage was still noticeably injured. The number of crops treated with ammonia-bordeaux was not so great as in case of the other three fungicides, but a sufficient number were treated, however, to give the mixture a fair trial.

On account of its caustic action upon the foliage, the use of ammonia-bordeaux can scarcely be recommended, although as a fungicide it was perhaps equal to any of the other three employed.

Ammonia-Bordeaux with Beets.

The ammonia-bordeaux was employed the present season as a preventive of beet leaf blight. In all, twelve applications of the mixture were made. The untreated beet plots were badly blighted, but the plot sprayed with the ammonia-bordeaux was comparatively uninjured. The fungicide, as used for the first three or four applications, was found to contain a larger percentage of ammonia than was necessary, the result being that the beet foliage so treated was severely burned. After reducing the proportion of the alkali, the degree of burning was materially lessened, but the objectionable feature was not wholly removed. As a result the yield of roots from that portion of the field so treated was but little more than half as great as in adjacent plots treated with other fungicides. Compared with its check

*Instead of Eau Celeste, a less caustic mixture, known as Modified Eau Celeste, is sometimes used, in which the carbonate of soda in addition to ammonia is employed.

plot there is seen to be a difference in the weight of roots produced of 16.1 per cent. in favor of the check. In weight of foliage, however, that of the sprayed plot was greater by 21.9 per cent.

Ammonia-bordeaux with Potatoes.

The six applications of ammonia-bordeaux to the foliage of one plot of Early Rose potatoes were void of any practical results since little or no blight appeared upon the crop considered. The foliage was badly injured by the fungicide and the weight of tubers produced in the plot so treated was much lower than elsewhere.

Ammonia-bordeaux with Sweet Potatoes.

A portion of a belt of sweet potatoes was sprayed eight times the present season with ammonia-bordeaux. At the time the spraying of this crop was begun the percentage of ammonia used was considerably lower than was that employed in the earlier application elsewhere, so that no such destructive results followed as in case of the round potatoes. The percentage of leaf mildew (*Oystopus Ipomœa-panduranae* Farl.) was noticeably less upon the vines sprayed with ammonia-bordeaux than upon those of the unsprayed.

Ammonia-bordeaux with Cosmos.

The degree of stem blight upon the two cosmos plants sprayed with ammonia-bordeaux was no less apparently than upon the untreated ones. Other spraying mixtures employed upon adjacent plants of the same sort gave equally unsatisfactory results. The foliage of the cosmos plants treated with ammonia-bordeaux was somewhat injured by burning.

EXPERIMENTS WITH CUPRAM.

The formula recommended for the preparation of cupram is as follows:

Copper carbonate.....	5 ounces.
Ammonia.....	3 quarts.
Water.....	60 gallons.

If enough water is first added to the carbonate to form a thin paste, it will be found to dissolve more readily upon the addition of the ammonia. After dissolving, dilute the solution with water to the desired strength. Cupram is a fungicide that is used by many, in preference to Bordeaux, on account of its being somewhat more easily prepared and less conspicuous upon the foliage. As a preventive of plant diseases, Bordeaux is considered somewhat superior to cupram, and was therefore selected in the experiments of 1895 and 1896 as the standard with which to compare trial fungicides.

TURNIPS AND CABBAGES.—The soil of one belt in the turnip series was treated in 1894 with cupram at the rate of 3,420 gallons per acre, for the purpose of destroying, if possible, the club-root fungus. The turnip plants were materially injured by the application, but the prevalence of the root disease seemed unaffected. The application of cupram in 1894 to the soil of one belt in the cabbage series, at the rate of 3,120 gallons per acre, was followed by like negative results.

POTATOES.—The belt in the cabbage series, treated in 1894 with cupram, at the rate of 3,120 gallons per acre, was planted to potatoes in 1895. Twenty per cent. of the potatoes from this belt were free from scab, whereas all the potatoes in the remaining belts of the same plot were badly scabbed. In the spring of 1896 a second application of cupram, at the rate of 4,320 gallons per acre, was made to the same belt, previous to its being planted to a second crop of potatoes. All the tubers harvested from this belt were scabbed, and to about the same degree as those in the check belt.

BEANS.—In the first and second bean crop of 1894, three belts were sprayed with cupram of double the strength called for in the above formula, and with full and half-strength solutions of the same fungicide. The percentage of blight was much reduced in the belts sprayed with the two stronger solutions, but the plants receiving the quarter-strength application were almost as badly infested as those of the check belts.

TOMATOES.—Six belts in the tomato series were sprayed with cupram in 1894, but as the crop was almost uninfested by leaf blight or fruit decays, no opportunity offered for testing the fungicidal merits of this solution.

CELERY.—In 1895 four belt rows were sprayed five times with cupram, at intervals of ten days. The amount of leaf blight at time of harvesting was about 3.5 per cent. less in the sprayed area than in the check, and the product by weight was greater than in the check by seventeen pounds. The amount of blight in the plants sprayed with cupram was about 3 per cent. higher than in those sprayed with Bordeaux.

BEETS.—The proposed sprayings of beets with cupram in 1894 were abandoned, owing to the fact that even a half-strength solution of the fungicide severely burned the beet foliage.

CABBOTS.—Double, half and quarter-strength solutions of cupram were applied to carrots in 1894. The percentage of leaf blight was light throughout the crop, but was noticeably less in the rows sprayed with the double and full-strength solutions. Half-strength was ineffective.

EXPERIMENTS WITH LIME.

TURNIPS.—Lime was applied in 1894 to three belts of the turnip series, 300, 150, and 75 bushels per acre, respectively. The results of the three years since these applications all show the excellent effect of lime as a remedy for the club-root. The reader may well consult the tables, under the head of "Experiments with Turnips," for a full statement of the effect of lime. After thorough tests for three years, it is evident that lime is not only a good remedy for the club-root, but also its effect lasts in large measure for three years.

SWEET POTATOES.—The Cinnamon field, where lime in various quantities was applied last year, has been continued in sweet potatoes the present season. The lime has had the effect of reducing the crop, and does not check the development of the soil rot. There is the same noticeable change of form of the roots from the ordinary shape to that of turnips. In short, lime does not agree with sweet potatoes, and cannot be recommended as a remedy for the soil rot.

EXPERIMENTS WITH CORROSIVE SUBLIMATE.

In the field experiments of this Department, corrosive sublimate has been used during the past three seasons, both as a liquid and in its usual powdered form. For soaking potatoes to destroy the scab

fungus, the solution usually recommended is prepared according to the following formula, which is referred to in this report as the full-strength solution :

Corrosive sublimate.....	1 ounce.
Water.....	8 gallons.

To dissolve, allow one gallon of hot water for each ounce of the sublimate and dilute to eight gallons. The chemical will dissolve much more readily if an equal weight of common salt is added to the water. The strength of a solution of corrosive sublimate, prepared according to the above formula, is not sufficient to injure the hands, but is a deadly poison if taken internally, and due precautions should accordingly be observed when using it. The solution should be placed in wooden or earthen vessels only.

In greenhouse experiments, the sublimate has either destroyed or materially interfered with the growth of plants when mixed with the soil in proportions smaller than 1 to 4,000 by weight.

TURNIPS.—In 1894 a full-strength solution of corrosive sublimate was applied to belt 6 of the first plot of turnips at the rate of 4,320 gallons per acre. The chemical in this instance appeared to have acted as a club-root fungicide, since the percentage of clubbed turnips produced in the belt so treated was much smaller in 1894 and 1895 than in the check belts of the same plot. In 1896 the proportion of clubbed roots in belt 6 was much increased, being in the first crop somewhat greater than in the check belt.

In 1895 powdered corrosive sublimate mixed with several times its bulk of earth, was evenly applied to two belts of Plot II. of the turnip series. To belt 2 the chemical was added at the rate of 33½ pounds per acre, and half as much was applied to belt 6. In both belts the percentage of clubbing has continued to increase, and in the belt to which the larger amount was added, the turnips have made but feeble growth for the past two seasons.

The decidedly negative results obtained in the two belts treated with powdered corrosive sublimate, suggests that the low percentage of clubbing in the belt to which liquid corrosive sublimate was applied may have been due to the soil of that belt having been exceptionally free from the club-root fungus at the beginning of the experiment rather than to any fungicidal action of the chemical applied.

POTATOES.—In 1894 three lots of seed potatoes were, previous to being planted in three different belts, soaked in, and sprayed in the open row with full, half and quarter-strength solutions of corrosive sublimate, respectively. The time of soaking varied from one hour for the full-strength solution to two and four hours for the half and quarter-strength solutions. Potatoes grown from the seed treated with the half and quarter-strength solutions were considerably freer from scab than were those grown from untreated seed in adjoining belts. On the contrary, the product of the full-strength belt was practically as badly scabbed as its check. Whether the lower percentage of scab in the half and quarter-strength belts had been due to the treatment received was therefore an open question.

In 1895 potatoes were grown upon another series, which gave evidence later of being thoroughly infested with the scab disease. The seed to be planted in four belts was first soaked for one hour in a solution twice the normal strength, normal, half and quarter strengths respectively. The entire product obtained from the belts planted with seed so treated was badly scabbed.

In 1896 the potatoes planted in one belt of Series II. were first soaked in a double-strength solution of corrosive sublimate, but the yield from this belt was as thoroughly scabbed as that from the check. Like negative results were obtained in Series VI. from soaking seed potatoes for two hours in full-strength corrosive sublimate.

BEETS.—The seed to be planted in one row of beets the present season was first soaked for two hours in a full-strength solution of corrosive sublimate, the purpose of such treatment being to determine whether or not the destruction of any spores that might be adhering to the rough surface of the seeds would make any perceptible difference later on in the degree of leaf blight. No such difference could be detected. The beet seed was apparently uninjured by the treatment.

EXPERIMENTS WITH KAINIT.

POTATOES.—Kainit was applied the present season to two of the belts in the potato series (II.), one at the rate of 600 and to the other 1,200 pounds per acre. Both amounts proved too large, the crop did not come up well and the missing hills were replanted. While the crop was small, some reduction of the scab is to be attributed to the kainit.

SWEET POTATOES.—The hold-over effect of the kainit applied to the sweet potato land in 1895 was such as to make the use of this substance hopeful as a remedy for the soil rot, especially when combined with sulphur.

EXPERIMENTS WITH COPPER SULPHATE.

TURNIPS.—In the spring of 1895, powdered copper sulphate was applied to one belt in the turnip series at the rate of 1,200 pounds per acre, and to another half as much was added. Neither application had any appreciable effect upon the clubbing, and the larger amount interfered seriously with the growth of the turnips.

A weak solution of copper sulphate (1 ounce to 8 gallons), with and without soap, was employed in 1895 as a leaf fungicide. Potatoes, beans, peppers, egg-plants, cucumbers, beets, and carrots were sprayed with the liquid, but as a preventive of blight it proved of no value, and some of the crops were seriously burned.

EXPERIMENTS WITH SULPHUR.

POTATOES.—The belt that was treated with sulphur, 300 pounds per acre, in 1895, was again in potatoes the present season and the crop escaped almost entirely the attack from the scab fungus. It was observed that the side rows of the three in the belt were not quite so free as the middle one. This is a demonstration of the good effect of the sulphur with the second crop, after it has been applied. Sulphur applied the present season, in amounts varying from 120 to 600 pounds per acre, all greatly reduced the amount of the scab. Many farmers who have used sulphur report favorably in all instances.

SWEET POTATOES.—The Cinnaminson field, where sulphur was applied last year in amounts varying from 2,500 to 625 pounds per acre, has been in sweet potatoes again this season, and, without any additional applications of sulphur, it is demonstrated that the soil rot may be greatly checked the second year after the sulphur is used. All three of the new field experiments with sulphur, in amounts ranging from 400 down to 50 pounds, gave similar results, all of them suggesting the profitable use of 300 pounds of sulphur upon land that is much subject to the soil rot.

TURNIPS.—Three of the turnip belts were treated with sulphur at the rate of 300, 600 and 1,200 pounds per acre, respectively. As a preventive of club-root, sulphur for the first year has been of no apparent value, and the largest application interfered with the growth of the turnips.

EXPERIMENTS WITH CARBONATE OF LIME.

TURNIPS.—To one belt of the turnip series, carbonate of lime was added in June at the rate of sixty bushels per acre. No good results were obtained in the next crop. The third crop is still upon the ground at the time of writing, and judging from the appearance of the growing plants this form of lime is wholesome to the crop and may equal the air-slaked stone-lime as a remedy for the club-root when applied in equal amounts.

PEAS.—One-half of a belt of the plot of peas was treated in June with sixty bushels per acre of the carbonate of lime, and gave excellent results. The third crop is still growing, and the results cannot be recorded for the present.

EXPERIMENTS WITH CARBONATE OF SODA.

TURNIPS.—Before planting the second crop of turnips, the present season, carbonate of soda (sal soda) was applied to the soil of one of the belts at the rate of sixty bushels per acre. The substance did not check the club-root and interfered materially with the growth of the turnips, the stand being less than one-half that of the checks.

Irrigation of Garden Crops.

Irrigation was begun upon the experiment area in September of last year, and the reader will find the details of the results then obtained given in the report for 1895, pages 309–317, and in Bulletin No. 115.*

The autumn of 1895 was remarkable for its small amount of rainfall, and the results of irrigation were quite favorable, as shown in the following summary :

*"Irrigation of Garden Crops," November 30th, 1895, with six engravings.

Summary of Results for 1895.

Irrigation, owing to the lateness in the season when the water was piped to the field, was confined to only a few weeks of autumn. Four crops received the water before it was too late for results to be obtained, namely, a second crop of bush beans, peppers, turnips (second crop) and late celery.

Irrigation is quite favorable to bush beans, there being nearly three times as many pounds of pods upon the belt receiving water as elsewhere in the field, besides the quality was far superior. The estimated cost for the increase of yield is forty-five cents per bushel.

Irrigation prolonged the period of fruitfulness with peppers, and the yield was nearly doubled. The difference in market value was still greater, for the watered plants yielded firm, plump fruits of fine color and quality, while the non-irrigated belts produced opposite results.

With the egg-plants, mulching, which in a sense is a mild form of irrigation, gave very encouraging results. It both greatly increased the yield of fruits and decreased the relative amount of decay.

Irrigation greatly increased the leaf development of turnips, and probably there would have been a corresponding growth of roots were it not for the club-root, which ruined the crop. The good effects of irrigation with turnips may be expected in land free from the club-root.

Irrigation for celery gave satisfactory results, considering the unfavorable soil and situation for growing this crop. In round numbers the crop was increased to two and one-half times that upon belts not receiving the water. In marketable product in pounds the difference was three to one, and in marketable value about eight to one in favor of irrigation.

IRRIGATION FOR 1896.

The present season may be characterized as approaching the normal in rainfall. Thanks are due to Mr. E. W. McGann for the accompanying meteorological tables, showing the rainfall at New Brunswick, N. J., for the past two seasons, March 1st to September 30th:

		Normal Average			
		1895.	For 10 years.	1896.	
March.....	3.21	4.09	March	5.92	inches.
April	4.59	3.15	April	1.77	"
May.....	2.72	3.63	May.....	3.89	"
June	3.03	3.84	June.....	4.86	"
July	4.24	4.99	July... ..	4.99	"
August	4.40	5.05	August	2.30	"
September	1.34	3.45	September.....	5.12	"
Totals.....	23.53	28.20		28.85	"

From this it is seen that the dry spell of the whole growing-season came in April, before many of the experiment crops were started.

During the present season irrigation has been used with a long list of crops, usually one of the six belts (fifth) of each plot being watered.

Irrigation of Turnips.

In the second turnip crop of 1895, the check belts of Plots II. and IV. in Series I. were surface-irrigated, the result being that while the amount of foliage produced by the plants so treated was noticeably greater, the root malformations, due to the club-root fungus, were correspondingly increased. The results of the experiment went to show that water might be applied with advantage to turnips during a dry season, provided the ground was not infested with the club-root fungus, in which case the additional water only increased the virulency of the root malady.

In the first turnip crop of 1896, the fifth belt of each of the four plots was surface-irrigated. Water was applied in the amounts and upon the dates given below :

May 7.....	50 gallons.	June 3	90 gallons.
" 9.....	800 "	" 5.....	945 "
" 10.....	500 "	" 6.....	1,400 "
" 11.....	800 "	" 8.....	300 "
" 15.....	500 "	" 9.....	45 "
" 16.....	700 "	" 12.....	275 "
" 18.....	375 "	" 13.....	1,620 "
" 19.....	500 "	Total	10,180 "
" 20.....	200 "		
" 23.....	1,080 "		

From the table of results presented on page 300, it will be seen that the amount of turnips by weight and the proportion clubbed were nearly the same for the irrigated as for a majority of the unirrigated belts. As was observed the previous year, the degree of clubbing was greater among the watered turnips than elsewhere.

To the fifth belt of Plot I., Series IV., 740 gallons of water were applied between May 8th and June 9th of the present season, with results essentially the same as were obtained for irrigation of the first crop in the four belts of Series I.

Irrigation of Potatoes.

Belt 5 in each of the four plots of Series II., devoted to experiments with potatoes, was subjected to irrigation. Owing to the fact that this series of plots occupies land with a gentle slope, it was possible to apply water at the upper ends of the rows to be irrigated. There were three rows of potatoes in each of the belts, and the water was applied at first in separate channels near the young plants, and later in the season, after the process of hilling had gone on, the water was added at the bottom of these channels midway between the rows of plants.

The amount of water and the dates of its application are given in the accompanying table:

May 6.....	90 gallons.	July 16.....	520 gallons.
" 11.....	300 "	" 18.....	180 "
" 12.....	75 "	August 6.....	440 "
" 14.....	200 "	" 7.....	300 "
" 15.....	150 "	" 10.....	720 "
" 16.....	150 "	" 12.....	600 "
" 19.....	675 "	" 13.....	580 "
" 23.....	1,075 "	" 14.....	320 "
June 6.....	1,350 "	" 21.....	300 "
" 8.....	300 "	" 25.....	450 "
" 9.....	40 "	" 26.....	350 "
" 30.....	450 "	" 29.....	375 "
July 1.....	180 "	September 1.....	900 "
" 2.....	450 "	" 2.....	760 "
" 3.....	280 "	" 3.....	200 "
" 4.....	200 "		
" 14.....	400 "	Total.....	13,785 "
" 15.....	375 "		

During the period of irrigation, expressed in the above table, there was no marked difference in the appearance of irrigated plants and those of the belts to which no water was applied, lying on either side.

Three varieties of potatoes were tested in this experiment with irrigation, there being two belts planted with Rural No. 2, and one each with the American Giant and the Early Rose. At harvest time the results were as shown in the tables on pages 315-317.

From that tabulation it may be gathered that the yield in pounds per belt for the irrigated area was as follows:

	Rural No. 2.	Giant.	Rural No. 2.	Early Rose.
Yield.....	76 pounds.	25 pounds.	107 pounds.	84 pounds.
Per cent. of scab....	75-	50	85	100

In the corresponding adjoining check belts the results were as given below:

	Rural No. 2.	Giant.	Rural No. 2.	Early Rose.
Yield.....	75 pounds.	34 pounds.	90 pounds.	55 pounds.
Per cent. of scab....	70	75	90	85

From this it is determined that the average yield per belt for the irrigated land is 73 pounds and that of the corresponding belts without irrigation 63.5 pounds, or an increase of nearly 9 per cent., while the average amount of scab upon the irrigated land was 77.5 per cent., and that upon its check belts 80 per cent. It will be seen that there is a slight and unprofitable gain in yield with less scabbiness of crop upon the belts that were irrigated.

Further Experiments in Irrigating Potatoes.

In one of the new series of plots added the present season to the experiment area, irrigation was used with potatoes. In this case the Early Rose was grown throughout the series. Here, again, the rows ran from the upper end of the series to the lower, with a descent advantageous for irrigation.

Water was applied in two different ways, namely, six rows received surface irrigation and a like number had the water added through tiles that were buried in the soil. The tiles were placed midway between two rows to be irrigated, and the depth at which they were

placed ranged from six inches for one row to eight inches for the next and ten inches for the third. The amounts and times of application of the water to the irrigated belts are given in the accompanying table :

		Surface Irrigation.			Sub-Irrigation.
May	6.....	420 gallons.			420 gallons
"	8.....	250 "			200 "
"	11.....	560 "			225 "
"	12.....	500 "			200 "
"	14.....	200 "			
"	15.....	200 "			
"	16.....				365 "
"	18.....	125 "			
"	19.....	3,100 "			180 "
"	20.....	200 "			180 "
"	24.....	500 "			120 "
June	3.....	175 "			
"	5.....	1,440 "	Total.....	1,770	"
"	8.....	720 "			
"	13.....	720 "			
July	1.....	720 "			
"	2.....	300 "			
"	3.....	370 "			
"	4.....	180 "			
"	13.....	200 "			
"	14.....	400 "			
"	15.....	450 "			
"	17.....	100 "			
"	18.....	120 "			
Total.....		11,950 "			

During the first few applications to the belt receiving the water upon the surface, channels were quickly made with a garden hoe alongside of the young potato plants. Later on the water flowed down the furrow made by the plow midway between the rows of potatoes.

With the subterranean tiles, some difficulty was experienced in distributing the water evenly over the whole area under irrigation. It was found that the descent was too rapid at the outlet of the tiles at the lower end of the line and the distance, 138 feet, was divided into four sections. The mouth of the lowermost tile of each section was stopped with old cloth, so that the water was applied from the upper end of the whole line to each of these sections successively.

From the table of results of the crop the following figures are drawn: the yield of potatoes for the six rows receiving surface irrigation is 451 pounds, and for the corresponding area with sub-irrigation it is exactly the same amount, 451 pounds. The three rows unirrigated and not otherwise treated gave a yield of 228.5 pounds, which, when multiplied by two for comparison, gives 457 pounds. These figures show that there is no real difference in yield between the irrigated and non-irrigated plants grown in this series under the conditions that prevailed during the past season.

With the exception of a single pound of smooth potatoes produced in one of the surface-irrigated rows, the entire yield of the sub and surface-irrigated rows, and the three check rows here considered, was scabbed. There was some difference as to the degree of scabbiness of the potatoes in different rows, but, as shown below, the average of the estimated scabbiness in the six sub-irrigated and in the six surface-irrigated rows was practically the same, and did not differ essentially from the average for the three check rows.

Average estimated scabbiness of sub-irrigated rows, 88.8 per cent.

Average estimated scabbiness of surface-irrigated rows 87.2 per cent.

Average estimated scabbiness of check irrigated rows, 89.9 per cent.

The second plots in Series III., IV. and V. were devoted to potatoes and the fifth belt in each plot was irrigated, the water being applied to the surface.

In Plot III. potatoes of the variety Rural No. 2 were grown and water was added to the irrigated belt as indicated in the following table:

May 6.....	80 gallons.	July 2.....	50 gallons.
" 7.....	200 "	" 3.....	180 "
" 8.....	180 "	" 4.....	35 "
" 11.....	380 "	" 15.....	40 "
" 14.....	180 "	" 16.....	20 "
" 16.....	40 "	Aug. 5.....	50 "
" 18.....	70 "	" 6.....	150 "
" 19.....	150 "	" 12.....	100 "
" 23.....	60 "	" 13.....	30 "
June 6.....	300 "	" 14.....	60 "
" 8.....	75 "	Total.....	2,605 "
July 1.....	75 "		

As will be seen by referring to the table of results on page 317, the proportion of scabbed tubers in Plot III. was greater in belts 4, 5 and 6 than in the first three belts. Had the percentage of scabbed potatoes been more nearly uniform in all the belts of the plot, the irrigated belt might be compared with that of belt 2 as well as with 4, both of which were planted, as was the irrigated belt, with cuttings from the middle of the potatoes. But since unirrigated belts upon one side of the field have less than 40 per cent. of their product scabbed, while the unirrigated upon the opposite side are practically all scabbed, it seems but fair to limit our comparison of the irrigated belt to the adjoining check belt (4). The yield and condition of the two belts were practically the same; the check produced 6.5 pounds more potatoes, and about five per cent. more of its product was scabbed than was that of the unirrigated belt. It may be said, therefore, that in this instance the addition of water did not appreciably affect either the yield or the percentage of scabbed potatoes.

In Plot IV., devoted to Early Rose potatoes, water was applied upon the dates and in the amounts stated in the table given below :

May 6.....	80 gallons.	July 2.....	50 gallons.
" 7.....	100 "	" 3.....	180 "
" 11.....	250 "	" 4.....	70 "
" 14.....	120 "	" 14.....	265 "
" 16.....	30 "	" 15.....	100 "
" 19.....	75 "	" 16.....	70 "
June 6.....	300 "	" 18.....	120 "
" 8.....	100 "	Total.....	2,265 "
" 12.....	80 "		
July 1.....	275 "		

The table of results on page 315 indicates that practically all the potatoes in all the belts were scabbed, except in the one to which water was added, and in this nearly 30 per cent. were smooth. Compared with belt 2, the yield of the irrigated belt is seen to be greater by 13 pounds and the percentage of scabbed tubers 27 per cent. less. Compared with the adjoining check belt (4), the yield is greater by 13 pounds in the irrigated belt, with 19 per cent. less of scabbed potatoes.

In Plot V., American Giant potatoes were grown, and in the following table are given the dates of application and the quantity of water applied at each time :

May 6.....	100 gallons.	July 2.....	50 gallons.
" 7.....	100 "	" 3.....	130 "
" 11.....	200 "	" 4.....	50 "
" 14.....	100 "	" 14.....	110 "
" 16.....	40 "	" 15.....	100 "
" 19.....	40 "	" 16.....	30 "
" 20.....	100 "	" 18.....	50 "
" 23.....	25 "	August 6.....	15 "
June 6.....	300 "	" 7.....	20 "
" 12.....	100 "	Total.....	2,030 "
" 30.....	150 "		
July 1.....	220 "		

The results obtained in the irrigated belt of this plot were somewhat different from those obtained in the irrigated belt of Plot IV. The yield in this instance was higher than that of any other belt, except belt 2, which exceeded it by five and one-half pounds. The percentage of scabbed potatoes in the irrigated belt was, however, greater than elsewhere, except in the adjoining "depths" belt (6). The proportion of scabbed tubers in belt 2 was less by 12 per cent., and in belt 4 by 16 per cent. The fact that the percentage of scabbed potatoes in belt 6 is twice as great as in the irrigated belt, suggests that the larger percentage of scab in the latter may have been due to causes other than that of additional water.

Irrigation of Peppers.

Very striking results were obtained in the belt of peppers to which water was added in 1895. The season of fruitage was extended and the total yield was nearly double that of the check belt, as the following table shows:

	Total Number Fruits.	Weight.	Measure.
Check belt.....	888	80 pounds.	6½ baskets.
Irrigated belt.....	1,277	147 "	11½ "

One of the belts in Plot I., Series III., devoted to peppers, was irrigated during the present season with the following amounts of water:

Upon May 23.....	75 gallons.	Upon August 6.....	150 gallons.
" June 3.....	135 "	" " 7.....	80 "
" " 5.....	90 "	" " 12.....	125 "
" " 6.....	250 "	" " 13.....	200 "
" " 13.....	270 "	" " 15.....	200 "
" July 1.....	180 "	" " 21.....	75 "
" " 2.....	50 "	" " 25.....	225 "
" " 3.....	160 "	" " 27.....	250 "
" " 4.....	30 "	" " 29.....	675 "
" " 14.....	227 "	" September 1.....	600 "
" " 15.....	50 "	" " 3.....	175 "
" " 16.....	30 "	" " 12.....	350 "
" " 18.....	35 "		
" August 5.....	200 "	Total.....	4,887 "

With eighty-four plants to a belt, this gave each plant in the experiment fifty-eight gallons of water. The average yield for the five unirrigated belts is 132 pounds, while that of the one receiving water is 130.3 pounds, or a loss of 1.7 pounds.

The experiment indicates that in a normal season irrigation is not advantageous to peppers.

Irrigation of Tomatoes.

The irrigated belt of tomatoes, Plot III., Series III., received the following amounts of water :

Upon May 16.....	225 gallons.	Upon August 7.....	130 gallons.
" " 18.....	200 "	" " 8.....	400 "
" " 19.....	100 "	" " 12.....	200 "
" " 20.....	100 "	" " 13.....	450 "
" " 23.....	50 "	" " 15.....	200 "
" June 6.....	300 "	" " 21.....	320 "
" " 8.....	35 "	" " 25.....	300 "
" July 2.....	275 "	" September 1.....	270 "
" " 3.....	90 "	" " 3.....	400 "
" " 15.....	200 "	" " 14.....	300 "
" " 16.....	130 "		
" " 18.....	40 "	Total.....	4,715 "

The above amount of water was applied to twenty-four plants, so that the average amount received by each was 196.4 gallons, or in round numbers, 200 gallons.

The table of results (page 335) shows that in the irrigated belt fewer fruits were produced than in the adjoining check belt or in any of the remaining belts. On the other hand, the number of spotted fruits was greater than in any other belt. Another effect of the

additional water, not shown in the above table, was that of the ripe tomatoes produced by the irrigated plants, fully two-thirds were cracked and therefore worthless. The plants in the irrigated belt were infested by leaf blight fully as much as were those of the check, but presented a somewhat better appearance, since they continued to grow and to put forth new leaves when growth had practically ceased elsewhere in the plot.

The results obtained indicate emphatically that irrigation of tomatoes is not advisable during a season in which there is a normal rainfall.

Irrigation of Egg-plants.

The fifth belt of egg-plants was surface-irrigated, each of the 39 plants receiving about 100 gallons of water during the season. Leaf blight and fruit rot were unusually prevalent in all the belts, and most of the fruits were destroyed before they had attained anything like a marketable size. The irrigated plants were not seen to be any more infested than those in adjoining belts. The yield, so far as could be determined under such circumstances, was not much above or below the normal.

Irrigation of Cucumbers.

The check belt of one of the cucumber plots (No. III. of Series V.) received water as stated in the following table :

May 16.....	75 gallons.	July 3.....	90 gallons.
" 18.....	40 "	" 4.....	60 "
" 19.....	40 "	" 14.....	200 "
" 23.....	20 "	" 15.....	90 "
June 6.....	230 "	" 16.....	50 "
" 12.....	80 "		
July 1.....	200 "	Total.....	1,175 "

A somewhat larger proportion of the young cucumber plants in this belt were destroyed by insects than elsewhere, and the yield was therefore lower than that of the adjoining check or cultural belt. The percentage of leaf blight in the irrigated belt was not noticeably greater than in either of the two unsprayed belts.

In the cucumber plot of Series IV. the check belt was irrigated from May 16th to August 12th, receiving in all about 1,800 gallons of water. Practically the same results were obtained as those just stated regarding the irrigated belt in the cucumber plot of Series V.

Irrigation of Beans.

The fifth belt of each of the two plots devoted to Golden Wax beans was assigned for irrigation, and water applied upon the dates and in the amounts shown in the table below.

Upon the old bean land, Plot I., Series V.:

Upon May 8.....	25 gallons.	Upon June 13.....	55 gallons.
" " 11.....	100 "	" " 30.....	150 "
" " 14.....	300 "	" July 1.....	90 "
" " 15.....	30 "	" " 2.....	30 "
" " 16.....	60 "	" " 3.....	30 "
" " 18.....	75 "	" " 4.....	50 "
" " 19.....	40 "		
" June 5.....	150 "	Total.....	1,230 "
" " 9.....	45 "		

Upon the new bean land, Plot IV., Series III.:

Upon May 8.....	25 gallons.	Upon June 6.....	300 gallons.
" " 11.....	100 "	" " 8.....	120 "
" " 12.....	25 "	" July 1.....	75 "
" " 14.....	225 "	" " 2.....	30 "
" " 15.....	30 "	" " 4.....	30 "
" " 16.....	75 "		
" " 18.....	40 "	Total.....	1,375 "
" " 19.....	300 "		

The increase of the irrigated belt on the old bean land (Plot I., Series IV.) over that of the adjoining check was 8.5 pounds, but it was due to the greater growth of tops, there being five pounds less of pods upon the irrigated than the check belt. As previously noted, the anthracnose was more than twice as abundant upon the irrigated than upon the check belt, but with the bacterial disease the amounts were reversed.

Upon the new land there was a much smaller total yield of beans from the irrigated than the check belt, but as for the old land the weight of tops greatly exceeded that of the pods where water was applied. The irrigated belt here also gave an increased amount, nearly double, of anthracnose over the check belt, and somewhat less of the bacterial blight.

For the second crop upon the old bean land (Plot I., Series V.) the water applied, with dates, is as follows:

Upon August 4.....	150 gallons.	Upon August 26.....	40 gallons.
" " 5.....	35 "	" " 29.....	75 "
" " 6.....	25 "	" September 1.....	40 "
" " 7.....	15 "	" " 2.....	75 "
" " 12.....	50 "	" " 3.....	90 "
" " 13.....	20 "	" " 14.....	60 "
" " 15.....	30 "		
" " 20.....	20 "	Total	740 "
" " 21.....	15 "		

In comparison with the check, the pods are found to weigh in the same notch, and the tops showed an increase of one pound. The anthracnose was practically absent from both belts, and while a large amount of bacterial blight was upon the pods of both belts, that of the check exceeding that of the watered belt as 13.7 to 11 pounds.

No profitable results were obtained by the irrigation of beans during the present season, when the natural rainfall was near the normal. It is evident that under such circumstances the anthracnose of the crop is considerably increased.

Irrigation of Peas.

The fifth belt in the plot devoted to peas (No. IV. Series V.) received water as indicated below :

May 6.....	150 gallons.	May 19.....	50 gallons.
" 7.....	50 "	June 1.....	50 "
" 8.....	30 "	" 3.....	40 "
" 11.....	100 "	" 5.....	45 "
" 12.....	25 "	" 6.....	350 "
" 14.....	75 "	" 8.....	85 "
" 15.....	40 "	" 12.....	70 "
" 16.....	40 "		
" 18.....	75 "	Total	1,275 "

As shown in the table of results on page 345, the yield of pods by weight from the irrigated vines was nearly 30 per cent. higher than that produced in any other belt, while the weight of the irrigated vines was more than double that of any corresponding area in the plot.

In the second crop the fifth belt was again irrigated. As stated elsewhere, the vines in all the belts were infested by blight to such an extent that few pods developed. The weight of the irrigated vines was somewhat less than that of the vines in the check belt and were fully as much infested by blight.

The results obtained from the irrigation of peas the present season

show that the application of water to early peas, especially during a dry season, would be profitable, and to late peas as well, provided means can be found for preventing the destructive blights, which are especially prevalent among peas at that time.

Irrigation of Celery.

In 1895 the celery was grown in single rows, and to each alternate row water was applied with very satisfactory results, which were summarized in the report for 1895 as follows: "In round numbers, the crop was increased to two and a half times that upon belts not receiving the water. In marketable product, in pounds, the difference was three to one, and in marketable value about eight to one in favor of irrigation."

During the present season surface and sub-irrigation was begun in the plot devoted to celery, but rains occurred with such frequency as to make the further addition of water superfluous and irrigation of this crop was therefore abandoned.

Irrigation of Beets.

Surface irrigation was tested in the plot devoted to beets. Six rows were liberally supplied with water throughout the season, the first applications being made previous to the appearance of the seedling plants.

The table below shows the amounts of water applied to the beets and the dates of its application :

SURFACE IRRIGATION.

May 7.....	800 gallons	July 15	1,400 gallons.
" 8.....	315 "	" 16.....	1,500 "
" 12.....	1,500 "	August 6.....	480 "
" 14.....	175 "	" 7.....	540 "
" 15.....	300 "	" 11.....	500 "
" 16.....	350 "	" 12.....	400 "
" 18.....	225 "	" 13.....	700 "
" 19.....	200 "	" 14.....	700 "
June 4.....	135 "	" 21.....	250 "
" 5.....	1,260 "	" 25.....	900 "
" 12.....	700 "	" 26.....	1,100 "
" 30.....	450 "	" 29.....	375 "
July 1.....	800 "	September 1.....	900 "
" 2.....	550 "	" 2.....	425 "
" 3.....	460 "	" 3.....	775 "
" 4.....	820 "	" 14.....	1,050 "
" 13.....	450 "		
" 14	830 "	Total.....	22,315 "

It was also intended to sub-irrigate an equal number of rows, and tiles were laid for this purpose, but owing to defective methods they became filled with earth during a heavy rain and were not again opened. The comparatively small amount of water introduced by this method during the second week in May was insufficient to have any appreciable effect upon the yield, and the six rows so treated are therefore included among the unirrigated.

It might be expected that so large an amount of water would either greatly increase or retard the growth of the plants so treated, but at no time during the season were the irrigated beets observed to be noticeably larger or smaller than the unirrigated. In the following table (Figure 44) is presented the yield by weight of roots and tops for each of the 32 rows:

Number of Row.	Weight of Tops.	Weight of Roots.
1	51.5 pounds.	222 pounds.
2	38.5 "	187 "
3	40 "	186.5 "
4	35.5 "	185.5 "
5	48.5 "	245.5 "
6	47.5 "	254 "
7	47 "	248.5 "
8	63 "	386 "
Replanted..... { 9	32.5 "	88 "
10	35.5 "	72.5 "
11	64 "	389 "
12	56.5 "	286 "
13	45.5 "	262 "
14	55 "	244.5 "
15	52 "	244 "
Surface-Irrigated. { 16	47.5 "	229 "
17	42 "	201 "
18	37 "	188.5 "
19	45 "	235.5 "
20	52 "	248 "
21	51 "	338 "
22	57 "	257.5 "
23	51 "	248.5 "
24	54 "	261 "
Sub-Irrigated (in- tended)..... { 25	62.5 "	318.5 "
26	63 "	285.5 "
27	66 "	302 "
28	61 "	298.5 "
29	62.5 "	240.5 "
30	85.5 "	343.5 "
31	86 "	249 "
32	72 "	400.5 "

Fig. 44.

Results of Beet Experiments for each of the 32 Rows.

If, in our comparison, we omit from the above table the last nine or ten rows, the yield of which is seen to be noticeably greater than that of the unirrigated rows elsewhere, it will be found that the average yield of roots and of tops for the six irrigated rows does not differ essentially from that of any six unirrigated rows.*

* Rows 9 and 10 contained two smaller varieties of beets and were planted considerably later than the remainder of the field, and should not, therefore, be considered in the comparison.

It was thought probable that the excessive watering would tend to increase the percentage of leaf blight among the beets so treated, and would, perhaps, favor also the development of beet scab, which had appeared on beet roots previously grown upon the same land.

Leaf blight, however, was no more noticeable in the irrigated belts than elsewhere, and the same may be said concerning the prevalence of beet scab.

The irrigation of beets in 1896 indicates that the addition of water to this crop during a season of average rainfall does not materially increase or diminish the yield and does not tend to increase leaf blight.

EXPERIMENTS WITH MULCHING.

In 1895, a mulch of old hay was applied to a portion of the plants of four different crops, namely, egg-plants, tomatoes, peppers, and cucumbers. The mulched belts, in each instance, were also sprayed with Bordeaux, while an adjoining one was bordeauxed, but not mulched, and served as a check.

Favorable results were obtained from mulching in every instance. In case of egg-plants the total number of sound fruits obtained from the mulched belt exceeded that from the check by 66.5 per cent. The mulched pepper and tomato belts when compared with their respective checks, each showed an increase in the number of sound fruits of about 13 per cent. The total yield of all three of the above belts was somewhat greater than that of their checks. In the mulched cucumber belt there was a falling off in yield, due to a poorer stand of plants, but there was a gain in the keeping quality of the fruits of 4.5 per cent.

In 1896, mulching was employed more extensively than during the previous season, the following crops being so treated: egg-plants, peppers, cucumbers, tomatoes, beans and potatoes. Fresh hay was again employed as a mulch, and, with the exception of potatoes, all the above-mentioned crops received also a mulch of excelsior and salt hay.

These three mulches were employed for the purpose of comparing their merits from a mechanical standpoint, and further to determine whether the plants mulched with one sort of material were noticeably superior or inferior to those mulched with another. Thus it was proposed to determine whether or not a material like fresh hay, contain-

ing nutritive properties that might be imparted to the soil upon which it is placed, would prove to be a fertilizer as well as a mulch, and on that account be more desirable than salt hay containing a considerably lower percentage of food elements, or excelsior, in which such elements are practically wanting. In order to more thoroughly test their efficiency as mulches, each of the three materials employed, instead of being confined to one were added to a portion of two belts. Thus, excelsior was applied to the sixth row of belt 1, sprayed with soda-bordeaux and to the first row of belt 2, sprayed with Bordeaux. Salt hay was used in the belt sprayed with potash-bordeaux (3) and the adjoining check belt (4). One row in the irrigated belt (5) and in the cultural (6), were mulched with fresh hay.

Since the chief value of mulching consists in its enabling the soil to retain its moisture, it is of course much more desirable during a season like that of 1895, when the rainfall was considerably below the normal, than when the soil contains an abundance of moisture throughout the season, as it did in 1896. In case of egg-plants, peppers, cucumbers, tomatoes and potatoes, there was no perceptible difference the present season between the mulched and unmulched rows either in yield or in prevalence of disease. As stated on page 330, the mulched rows in the first crop of beans gave a somewhat larger yield, but there was no practical difference as to the prevalence of leaf blight or pod spot. In the second crop, the yield and percentage of disease were essentially the same in the mulched and unmulched rows.

Excelsior does not become matted down and decomposed as does salt or fresh hay, but might for that reason prove to be less valuable as a mulch during a dry season. Being more expensive than salt or fresh hay, it is most likely to be employed in small gardens only. Fresh hay did not give evidence of having acted as a fertilizer, and since more of it is required to mulch the same area than is required of salt hay, the latter is to be preferred.

The experiments with mulching during the past season, indicate that such treatment is highly beneficial during a dry season, but of practically no value during one in which there is an average and uniform rainfall.

The following table gives the results of mulches with beans :

	Soda- Bordeaux.		Bordeaux.		Potash- Bordeaux.		Check.		Irrigation.		Depths.	
	Unm.	Mul.	Unm.	Mul.	Unm.	Mul.	Unm.	Mul.	Unm.	Mul.	Unm.	Mul.
Pods.....	58.5	66.6	72	99	66	108	89	93	96	87	Not comparable.	
Tops.....	68.5	57	77	81	70	78	84.5	102	108	90		
Total.....	122.1	123.5	149	180	136	186	173.5	195	219	177		
Gain for mulch.		1.4		81		50		22.5	22 less.			

DEPTH OF SOWING AND PLANTING.

In a portion of the land in beets, beans and peas the seed was sown at definite depths below the normal, with the view of studying the effects upon the crop of such seed treatment, and in particular the susceptibility of the plants to disease.

Beets.—Three rows of beets were sown at depths of two, four and six inches respectively. All seed covered four or six inches failed to germinate, but that at a depth of two inches developed about as readily as did the seed in adjoining rows at a depth of one inch. No difference in disease was observed.

Potatoes.—In each of the three belts devoted to a test of depths, one of the three rows had the seed placed in a trench eight inches below the surface, the next row six inches and the third four inches deep. The total for the three depths of all three varieties is as follows—drawn from a previous table:

	DEPTHS—		
	8 inches.	6 inches.	4 inches.
Total.....	54.5	65.5	50
Scabbed.....	48.5	55.5	44.5
Clean tubers.....	6	10	5.5

It is seen that there was the largest yield with the six-inch depth, and also the largest percentage of scab. This agrees with the results obtained with long beets, namely, that the greatest amount of scab germs is in a narrow belt a few inches below the surface. There is a possibility that the process of hilling may be a matter worth considering in connection with the scab.

Beans.—In the first crop of beans the seed was sown in the sixth belt of both bean plots at three different depths, namely, one, four and six inches, respectively. As a result, only about half as many seeds germinated in the six-inch planting, and about two-thirds as

many in the four-inch planting, as in the two rows in which the seed was sown one inch deep.

In the second crop of beans in Plot V. the experiment was repeated, but instead of filling the six and four-inch drills at once, the seed was covered about two inches and earth was gradually added as the plants developed. The stand of plants was almost exactly the same in all the rows, and when harvested the four and six-inch rows gave almost exactly the same weight of tops and sound and spotted pods. Their yield of tops and pods was somewhat less than that of the average of the rows in the remaining belts of the plot. The first four rows in the depths belt cannot be compared with the other two in the same belt, owing to the growth of the latter having been materially interfered with by an adjoining excavation. The experiment goes to show that the sowing of beans at depths greater than the normal is of no advantage, at least in a season of average rainfall.

Peas.—Depths experiments were introduced in the sixth belt in both crops of peas. The plan of the experiment for both crops was as indicated below :

Two rows planted four inches deep and hilled up gradually.

Two rows planted two inches deep and hilled up two inches.

Two rows planted on surface and gradually hilled up to four inches.

The yield by weight of pods and vines was the same for the last two pairs of rows in the above table, and each was greater than that of the first pair by three pounds. In the second crop the yield of the first pair and second pair was about the same and greater than the first. In both crops the product of the depths rows was less than that of the average of the rows in the first five belts.

EXPERIMENTS WITH ORNAMENTAL PLANTS.

A piece of land of about a tenth of an acre lying between the border grass plots upon the west side of the experiment area and Series VI. is assigned to field tests of fungicides upon ornamental plants. In this "field hospital" for flowering herbs and shrubs, a number of kinds of ornamental plants have been treated during the present season. The following notes are upon these several crops, and are given below in the order of their arrangement, row by row, stretching lengthwise of the field, beginning, with pæonies upon the outside border and ending with cosmos next to the field crops :

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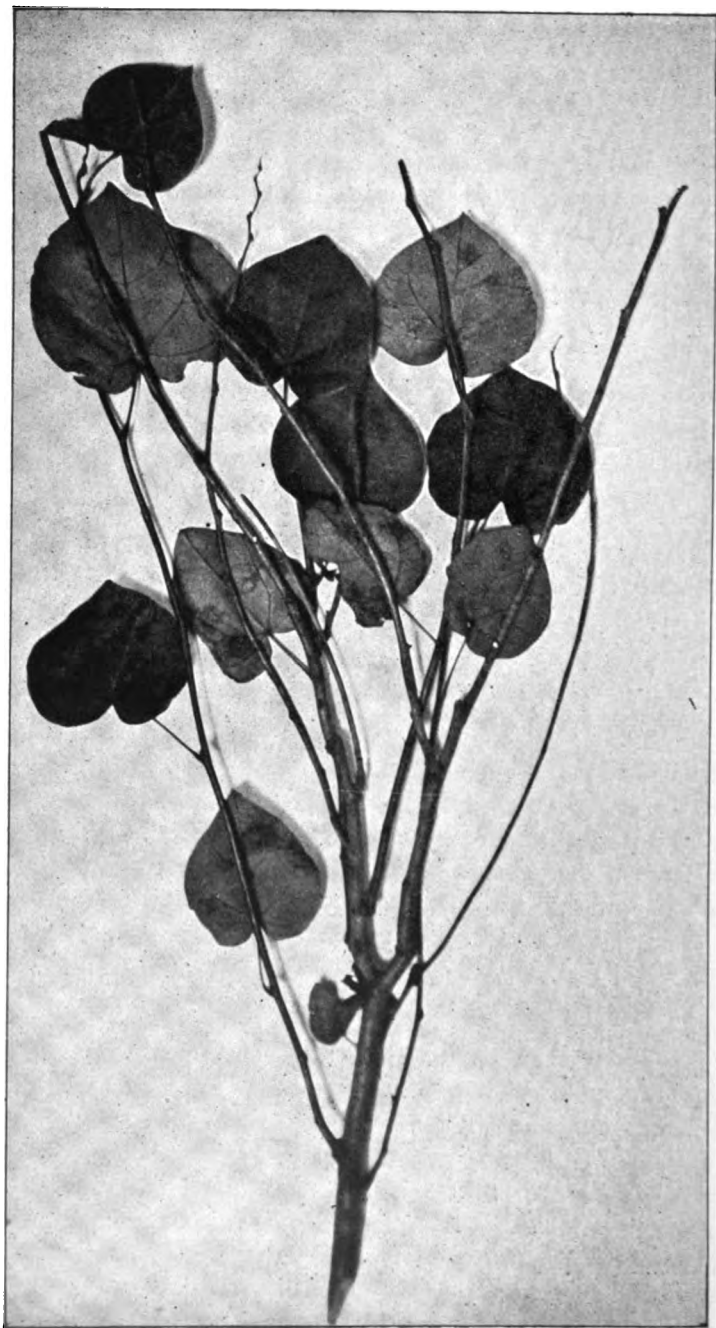


Fig. 47.
Branch of *Cercis* badly affected with the Blight.

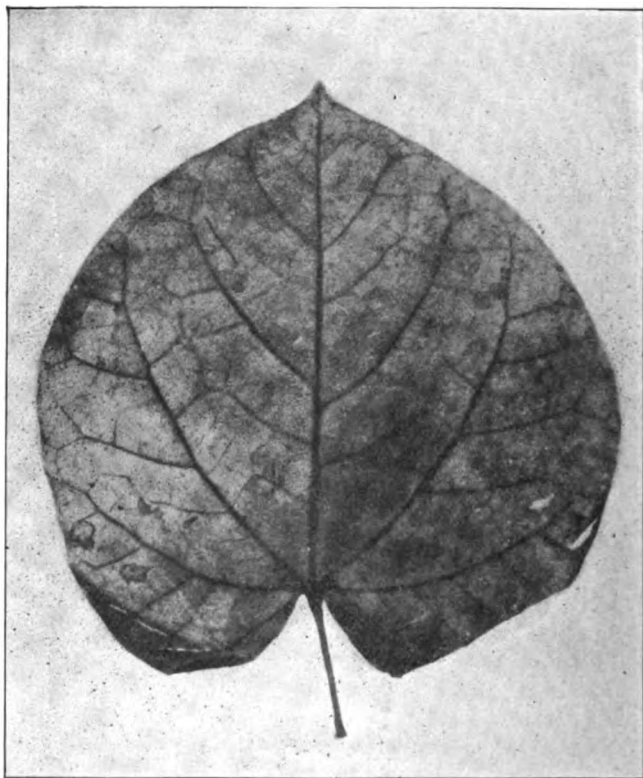


Fig. 46.
Average Cereus Leaf from Sprayed Plants.

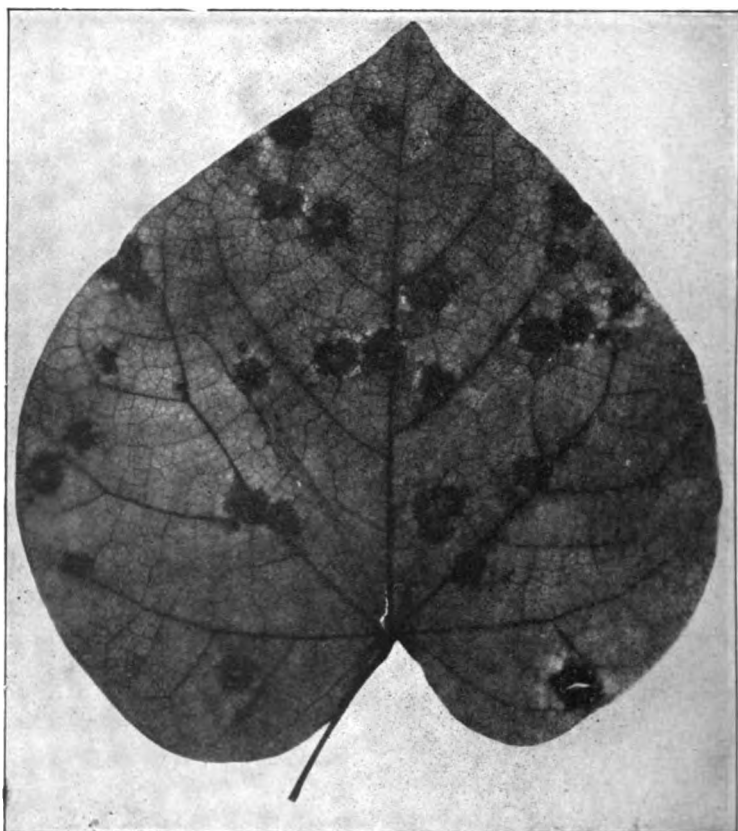


Fig. 45.
Average Cercis Leaf from the nursery rows.

Experiments with Pæonies.

In the outermost row of the ornamental plants, adjoining the grass plots, large pæony plants were set. Two of these plants were sprayed for the pæony blight with Bordeaux, two with soda-bordeaux and two with potash-bordeaux, and the remaining six were left unsprayed. The blight did not make its appearance and therefore no results, comparative or otherwise, can be recorded for the fungicides.

Experiments with Japanese Redbud.

The Japanese redbud (*Cercis Japonica*) is seriously attacked by a leaf spot (*Cercospora cercidicola* E.) Two dozen plants were set in a single row in the area devoted to ornamental plants and sprayed with three fungicides.

At the close of the season there was no marked difference between the sprayed and unsprayed plants, all of them being comparatively healthy.

A visit was made in September to the nursery from which the plants had been obtained, and at that time the Japanese redbud plants by the thousand in the nursery rows were nearly all leafless from a severe attack of the *Cercospora*. The difference between these plants and those taken from the same rows in the spring and introduced into the experiment grounds was most marked. Neither the sprayed nor the unsprayed plants were so badly blighted as those that remained in the nursery rows. This seems to be a striking illustration of the healthfulness that may follow the removal of plants from a locality where its kind has been grown for a term of years in considerable numbers and a disease has developed to a serious extent.

An average leaf from the best plant found at the nursery is shown in Figure 45, while a corresponding average leaf from the best sprayed plant at the experiment grounds is shown in Figure 46. Both of these engravings are from sun-prints, and therefore show the leaves actual size and with the various details.

That the reader may gain a better idea of the extent of the injury of the *Cercospora*, a branch is shown in Figure 47 from a blighted plant from the nursery. This *Cercospora* is not confined to the foliage, but attacks the young twigs and often girdles them and causes

their death. The engraving shows that some of the twigs are dead, while others have attempted to supply their places and are victims to the same enemy.

The writer does not wish to close this item in the report without emphasizing the fact here brought out, namely, that the mere removal of perennial plants from their association with diseased specimens, and placed somewhat isolated upon new land, has a marked tendency to check the fungous enemy. In the present case, the plants were so healthful as to leave but little to be done by the fungicide.

Experiments with Hollyhocks.

One row of hollyhocks (*Althæa rosea* Cav.) was introduced into that portion of the experiment area devoted to ornamental plants. The plants were grown from seed in the greenhouse, and when three months old went into the open ground. The row was divided into six sections, with six plants in each section. Three of these sections were treated with fungicides and three remained as checks. The sprayings were eleven in number, at intervals of about ten days. Very favorable results were obtained, the leading fungus being the leaf blight (*Cercospora Althæina* Sacc.)

The accompanying engravings, Figures 48 and 49, made from sun-prints, show the relative amounts of the fungus upon the plants sprayed with the Bordeaux, soda-bordeaux, potash-bordeaux and the check.

Experiments with Gladiolus.

Two rows adjoining the hollyhocks were set to gladiolus. The bulbs (corms) were a diseased lot that had been sent to the Station for examination. Before being planted they were divided into uniform groups and each lot subjected to a different treatment, as follows:

- No. 1. Soaked in kainit solution, 1 to 100, two hours.
- " 2. Soaked in hot water, 200° F., quarter of an hour.
- " 3. Check. No treatment.
- " 4. Soaked in corrosive sublimate, 1 to 1,000, two hours.
- " 5. Rolled in sulphur.
- " 6. No corm treatment. Sprayed with soda-bordeaux.
- " 7. No corm treatment. Sprayed with Bordeaux.
- " 8. Check.
- " 9. No corm treatment. Sprayed with potash-bordeaux.
- " 10. No corm treatment. Sprayed with ammonia-bordeaux.

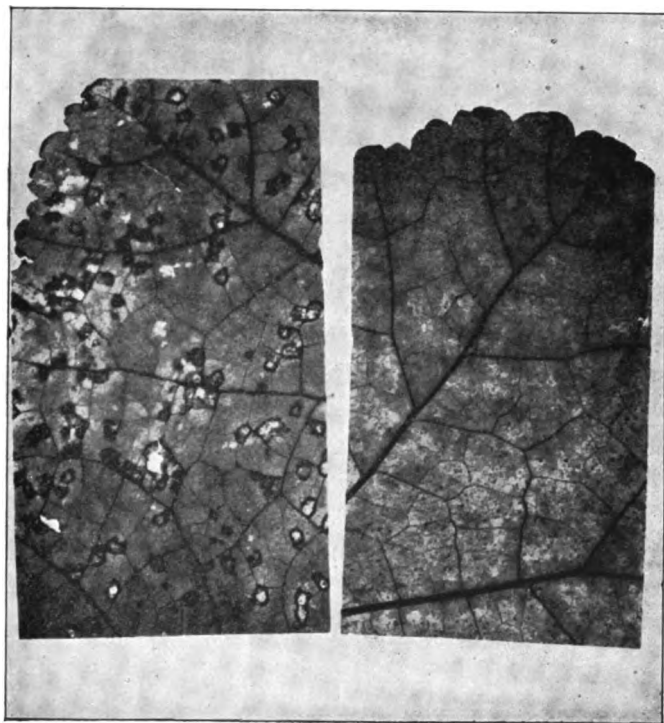


Fig. 48.
Portion of Hollyhock Leaf from Check plant (right), and one (left) sprayed with
Soda-Bordeaux.

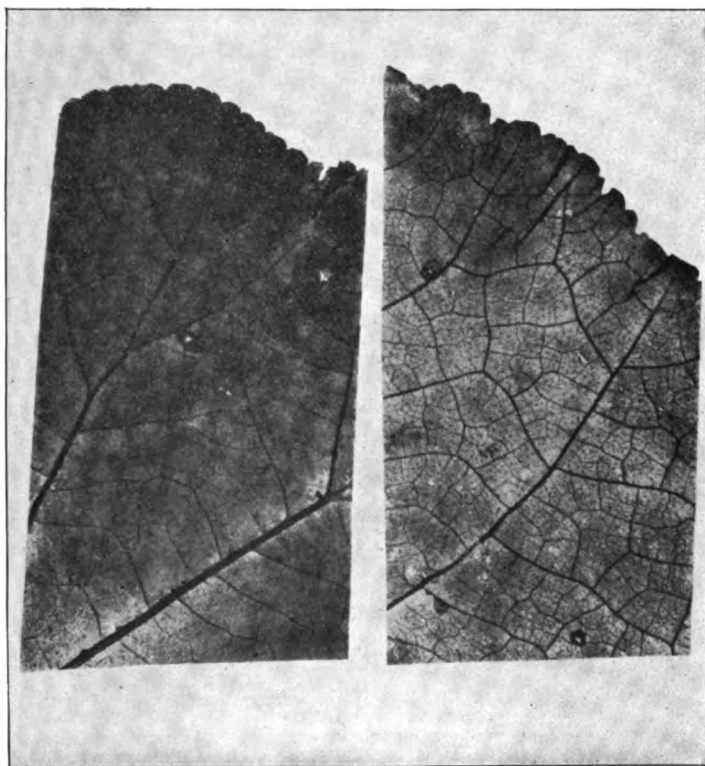


Fig. 49.

Portion of Hollyhock Leaf (right) from plant sprayed with Bordeaux, and one (left) from plant sprayed with Potash-Bordeaux.

It will be seen that half of the lots were treated before planting, and the other half received sprayings with fungicides, there being a check for each of the two halves.

The rows in the field were divided into ten equal portions, nearly fourteen feet to each section, and twenty corms were set in each, and in the order given in the above table, beginning with the northern end of the rows.

The sprayings were eleven in number, and during the whole growing-season no difference was noted between the sprayed and unsprayed plants. The smooth surface and upright position of the gladiolus leaves prevent, in large measure, the satisfactory adhesion of the fungicides.

In the corm-treated section there are some minor differences in the harvest. The lot of corms from the check section is the smallest, while the ones from where the corrosive sublimate and the sulphur were used are nearly equal and somewhat larger than the others. These corms are to be planted in the same ground next year, and the experiment is therefore not yet at an end.

Experiments with China Asters.

The row next to the sweet peas was set with six varieties of China asters from seed that has been sown in the greenhouse. This experiment was for the purpose of finding some way of getting control of the rust (*Coleosporium Sonchi-arvensis?*) that is often very abundant upon these plants. One variety of the asters was badly attacked and ruined by a stem blight; but the rust was almost entirely absent from all the plants.

Experiments with Sweet Peas.

A somewhat extensive series of tests was made with sweet peas with the hope of finding a remedy for the root and stem trouble so much complained of during the past few years.

A single row in that portion of the experiment area devoted to ornamental plants was sown to sweet peas. The row was divided into sections nine feet long, and received treatment as indicated in the following table:

Section	1.	Seed placed upon surface, hilled up 5 inches.						
"	2	"	"	"	"	"	3	"
"	3.	"	"	2 inches deep,	"	"	2	"
"	4.	"	"	5 "	"	"	4	"
"	5.	"	"	3 "	"	"	2	"
"	6.	"	"	1 inch	"	"	1	"
"	7.	"	"	3 inches	"	"	3	"
"	8.	"	"	5 "	"	"	5	"
"	9.	"	soaked in Bordeaux				1 hour,	2 inches deep.
"	10.	"	rolled in sulphur				1	" 2 " "
"	11.	"	soaked in corrosive sublimate				1	" 2 " "

The sowings were upon June 29th, purposely late, in the hope that the root and stem troubles might thereby be more abundant.

The plants in all the sections grew equally well, were very vigorous and showed no signs of the trouble.

Experiments with Cosmos.

One row of that portion of the experiment area devoted to ornamental plants was set to cosmos, and treated with fungicides, especially for the much-dreaded stem blight (*Phytophthora* sp.) The row was divided into six sections of twenty-three feet each. Two of these were checks and the other four were sprayed eight times, at intervals of ten days, with Bordeaux, soda bordeaux, potash-bordeaux and ammonia-bordeaux, respectively. Posts and wires were employed to keep the plants from breaking down and becoming prostrate upon the ground. The stem blight developed equally upon all the sections, and no favorable results were obtained for the fungicides.

Experiments with Lawn Grasses.

It was desired to have a grass border at each end of the experiment area, and opportunity offered for testing the comparative value of several lawn grasses. The strip of land upon the west side is about twenty-one feet wide at the upper end and narrows down to half that at the lower end. Along the roadside and separating it from the ground devoted to ornamental plants, nine kinds of grasses were tested upon as many small plots, $15\frac{1}{2}$ feet in one direction, and varying from 10 to 20 in the other. The following seeds were sown, beginning with the uppermost plot and nearest to the greenhouse :

		Per cent. of Stand.
Plot	I. Meadow Fesque (<i>Festuca pratensis</i> Huds.) Kansas seed.....	90
Plot	II. Five-leaved Fesque (<i>Festuca tenuifolia</i> Sibth.) Imported seed.....	5
Plot	III. Sheep's Fesque (<i>Festuca ovina</i> L.) Imported seed	10
Plot	IV. Rhode Island Bent (<i>Agrostis canina</i> L.) Rhode Island seed.....	80
Plot	V. Wood Meadow (<i>Poa nemoralis</i> L.) Imported seed.....	60
Plot	VI. Kentucky Blue Grass (<i>Poa pratensis</i> L.) Kentucky seed.....	50
Plot	VII. Rough-stalked Meadow Grass (<i>Poa trivialis</i> L.) Imported seed.....	90
Plot	VIII. Redtop (<i>Agrostis alba vulgaris</i> (With.) Thurb.) New Jersey seed..	100
Plot	IX. Bye Grass (<i>Lolium perenne</i> L.) Scotland seed.....	100

All of these plots received the same treatment, which consisted in running the lawn mower over them to keep down the weeds. At the time of writing, November 17th, there is quite a difference between the several plots. Upon the basis of a stand of plants, in terms of percentages, the nine plots are as given at end of each line. It will be seen that the Rye grass and Redtop are both perfect, followed closely by the Rough-stalked Meadow grass and the Meadow Fesque. The Rhode Island bent is fifth, Wood Meadow sixth, Kentucky Blue grass seventh, while Sheep Fesque and Five-leaved Fesque were very poor.

No mixtures were tested, but the results for the past season with sorts grown alone would indicate that the first five above named would give a satisfactory combination. The glossy richness of the foliage of the Rye grass was an object of remark. This is a coarse grass that would mix well with Redtop and the Meadow Fesque.

The plots at the opposite end of the experiment-area did not do so well, as they were in the shade, and were left without care as a severe test of their ability to endure neglect. They were much overgrown by weeds, and more time is needed before judgment can be passed upon this series of plots.

The Herbarium.

During the past year the accessions of the Station Mycological Herbarium have been a few hundred specimens, thus bringing the total up to about 21,000 and representing the following sets of fungi :

Ellis and Everhart's North American Fungi.....	3,300
Seymour and Earle's Economic Fungi.....	450
Sydow's Uredineae.....	1,050

Sydow's Mycotheca Marchiae	4,600
Kreiger's Fungi Saxonici Exsiccati	1,050
Lindhart's Hungarian Fungi.....	400
Briosi and Cavara's Fungi Parassiti.....	225
Cavara's Fungi Longobardiæ Exsiccati.....	250
Roumel's Fungi Exsiccati Scandinavici.....	200
Von Thuemen's Mycotheca Universalis, Vols. 6 to 12, inclusive.....	700
Arthur and Holway's Uredinæ Exsiccatæ et Icones	50
Allescher and Schinabl's Fungi Bavarici Exsiccatæ. Cents. III. and IV....	200
Erikson's Fungi Parasitici Scandinavici. Cents. VII to X.....	400
Ravinel's Fungi Caroliniani Exsiccatæ. Cent. III.....	100
Sydow's Phycomycetes. Fasc. I.....	50
Sydow's Ustilaginæ. Fasc. II.....	100
Von Thuemen's Fungi Austriaci Exsiccatæ. Cents. VII.-XII.....	600
Heller's Hawaiian Fungi	30
Pringle's Mexican Fungi.....	10

The work of carrying on the card index for both the species and the hosts has been continued at intervals during the year, and the host index is complete up to date.

Work with Weeds.

Many weeds for determination have been sent to the Station, and occasionally commercial seeds suspected of containing foul stuff have been submitted for inspection. The work in this direction has suggested the need of some easy and rapid method of studying seeds.

A Weed Seed Holder.

An improvement has been made upon the old method of holding weed seeds for purposes of comparison of suspected commercial seeds. Instead of the dram screw-cap bottles, one hundred in a tray, a case has been constructed consisting of a piece of cherry a foot square and one inch thick, having one hundred pits bored into one side for holding the seeds, as shown in Figure 50. Over the pits holding the seeds, a glass is closely fitted by means of a narrow border that surrounds the holder.

These seeds are arranged in the same order as those of the trays, and a number is stamped below each pit corresponding to a printed list that is pasted upon the bottom of the holder. Light-colored

seeds are glued to a black background placed in the bottom of the pit, while dark seeds are made more conspicuous by being placed upon white paper.

The seed to be examined is scattered upon the glass cover of the holder, and the kinds of foul seeds determined by matching them

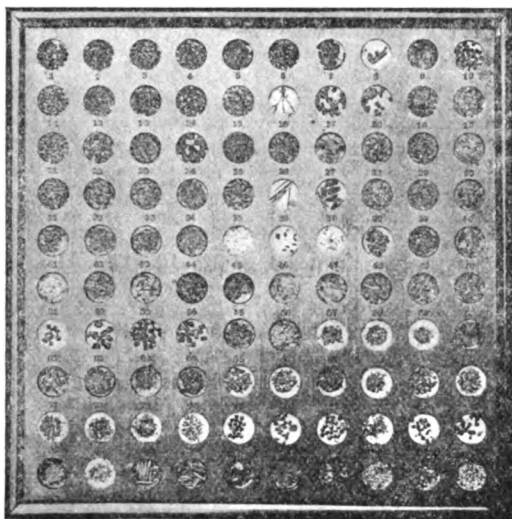


Fig. 50.

A Case for Examining Seeds for Foul Stuff.

with those in the pits directly below the glass. The seeds are removed by tipping the holder and letting them run through a slot left in the border at one corner.

The Russian Thistle.

In the report of last year, pages 348-351, mention was made of the introduction of the Russian thistle (*Salsola Tragus* L.) into New Jersey at the Weehawken station of the West Shore railroad. The discoverer, Prof. Wm. H. Van Sickle, has gone carefully over the region in and around Weehawken the present season, and is able to report that his gathering and burning of the pest last autumn have proved effective, and at the date of his communication, October 20th, 1896, he is able to report that he finds "no trace of *Salsola Tragus* in the Weehawken yards this year."

The notice of the advent of the enemy last year put the crop-growers upon their guard, and some have thought it had been dis-

covered elsewhere in the State, but upon examining samples they were found to be of a closely-related species, the saltwort (*Salsola Kali* L.), that is quite widespread along the seashore from Maine to Florida and is not harmful to cultivated crops. It differs from the Russian thistle in having the leaves and outer branches green and the whole plant less bushy and more fleshy than its pestiferous relative. Engravings of the intruder were given in the report for last year.

DODDER UPON GARDEN VEGETABLES.

During the present season samples of two kinds of truck crops have been sent to the Station that were attacked by dodder. The first lot was that of seedling, egg-plants from a hot-bed, the young plants being overrun by the orange-colored threads of the parasite. A second lot was of onions in the open field upon which the dodder had made itself at home. While it is not uncommon to find wild plants, particularly in low ground, covered with the dodder, it is unusual to find it within the cultivated field, and still less so in the hot-bed.

As seen upon the wild herbs and shrubs, it is frequently so rampant as to give the prevailing color of the wire-like threads to the verdure of the attacked area. The reader can get an idea of the appearance of the dodder upon onions from Figure 51,* which is made from a sun-print, and shows the tangled mass of threads as attached to some of the onion leaves. This weed produces numerous flowers, some of which may be seen in the engraving, ripens abundant seeds, which germinate in the soil, and the slender plants afterwards attach themselves to the onion or other host by means of small roots, and through them obtain the nourishment needed for further growth.

There are several species of dodder, one of which (*Ouscuta Epilinum* Weihe) grows upon the flax and often does much damage to this crop. Occasionally complaints are made of a dodder (*Ouscuta Epithymum* Murr.) upon the clovers.

Along with the specimens of dodder upon onions came the statement that "it is increasing every year," which only suggests that truckers should be watchful for these intruders, and realizing that they are flower and seed-bearing plants, destroy them at first sight. Use clean seed and let no dodder go to seed.

* Published in "Garden and Forest" for September 9th, 1896.



Fig. 51.
Dodder upon Onion Leaves

EXPERIMENTS WITH WATER-LILY BLIGHT.

During the past season there have been complaints made of a serious blight of the water lilies in the artificial tanks and ponds of the growers of aquatics. The appearance of a diseased leaf of a

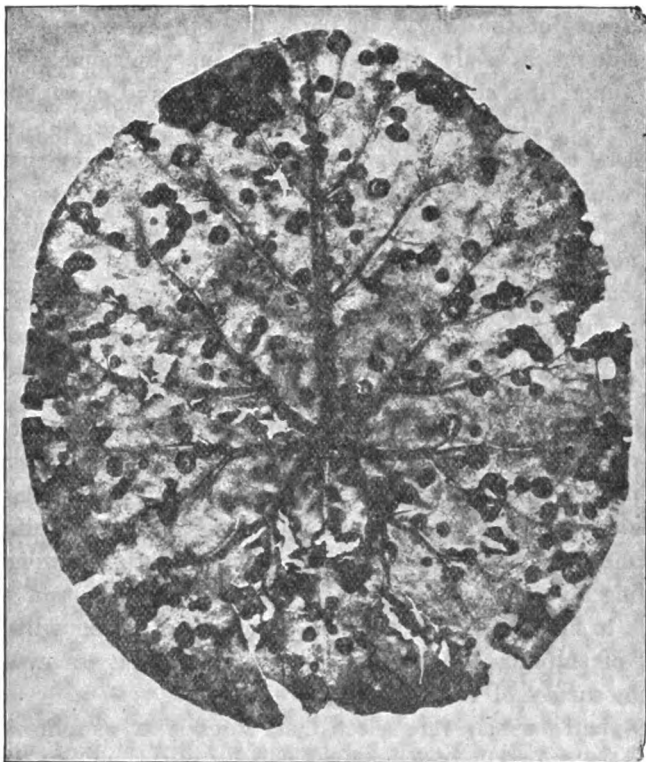


Fig. 52.

A Blighted *Nymphaea* Leaf.

nymphaea is shown in Figure 52,* made from a sun-print, and therefore giving all the details in natural size.

The disease is caused by a species of *Cercospora*, and therefore a member of a large genus, noted for producing small dead areas in the foliage, from which fact the term "leaf spot" is given to

*Under the title of "Leaf Spot of Water Lilies," a short article was published in the "American Florist," for September 5th, from which the above cut has been kindly loaned by the publishers.

many species of the genus. For example, the *Cerpospora beticola* Sacc., causing the familiar spotting of the foliage of the beet, is a near relative of this trouble of the water lilies.

The affected portions of the nymphæa leaf at first lose their normal green color, changing to a yellow and finally a dark brown, after which the dead tissue may break away, leaving small holes in the leaf. Spores of the fungus are borne upon the surface of the spots, and are doubtless easily disseminated by the water and quickly germinate upon the surface of healthy foliage, and thus spread the disease.

Unusual conditions for the propagation and spread of the trouble, obtain with such water plants, and at the same time the ordinary methods for checking it do not seem promising. As subterranean fungi need to be met in the soil, so here it seemed best to add to the water some fungicide, with the hope of checking the disease in the plants it surrounds.

Two lines of experimentation suggested themselves, namely, the use of the ordinary fungicides that have proved effective upon terrestrial plants; and secondly, the adding of fungicides that are but slightly soluble and will float in the water, thereby keeping the foliage of the plants in contact with the remedy. Two of the standard liquid fungicides were employed, and sulphur and a half-and-half mixture of sulphur and oxide of copper were used as floating powders.

Failing to get a preparation of the oxide of copper of sufficient fineness to float, it was thoroughly ground in a mortar with its own weight of sulphur (much more in bulk), when it was easily borne upon the surface of the water.

Tubs (half barrels) were selected, six in each set, as follows :

Bordeaux.	Check.	Sulphur.
Oxide of copper with sulphur.	Check.	Cupram.

These were in duplicate, and later on the substances were introduced into the vats under glass and the pools in the aquatic gardens.

The Bordeaux was satisfactory as a fungicide, but objected to by the gardener on account of the incrustation of lime upon the foliage,

which was much worse than with ordinary land plants when sprayed with the same mixture.

The cupram was preferred to Bordeaux, but needs to be used in weak solution.

The use of the sulphur was not continued, because of the unattractive appearance it gave to the water and foliage of the plants, coating all with its yellow scum.

In the language of the gardener in charge, "the oxide is good," and then he adds in a recent letter, "especially for dusting plants that are liable to 'damp off.'" This mixture of oxide and sulphur has a grayish color and is not conspicuous, and therefore not objectionable, like sulphur, when added to tanks of water plants.

This single series of experiments indicates that the Bordeaux is the most satisfactory of the four substances employed, and when its objectionable feature is removed, namely, the lime, the case of diseased water lilies will be fairly met with a fungicide. There is no reason to doubt that the potash-bordeaux will prove effective and satisfactory, and it is the intention to make a thorough trial of it the next year.

A secondary advantage gained by these fungicides was the destruction of the green filaments, algæ (*confervæ*), that often prove a menace to the satisfactory growing of water plants. The Bordeaux, for example, in a few days after its first application, began to kill the fine green growth, and in a few weeks the pools were free from it, much to the delight of the gardener.

DISEASES OF THE ASPARAGUS.

Up to the present year there have been but few complaints of fungous troubles with the asparagus. Early in September the growers of this crop became much exercised over a premature maturing of their asparagus fields and sought the Experiment Station for advice. The trouble was a rust that had been so general and complete in its attack as to warrant the alarm. Within a week after, an examination was made of fully two hundred acres of asparagus plants. A circular essentially as given below was issued to the press of the State and other newspapers that circulate in New Jersey:

"AN OUTBREAK OF THE ASPARAGUS RUST.

"The Experiment Station has had its attention called to an unusual development of rust upon the asparagus plant, and as this is new and somewhat alarming to the truck-growers of the State, the following items are published for their especial benefit:

"General Appearance of the Field.—When an asparagus field is badly infested with the rust, the general appearance is that of an unseasonable maturing of the plants. Instead of the usual healthy green color, the field has a brownish hue, as if insects had sapped the plants or frost had destroyed their vitality.

"Close View of the Plants.—Rusted asparagus plants, when viewed closely, are found to have the skin of the stems, both large and small, lifted as if blistered, and in the ruptures of the epidermis dark-brown spots are readily seen. These brown dots or lines are of various sizes and shapes, and remind the close observer of similar spots in the broken skin of stems of grains and grasses and of the leaves of corn, also due to rusts, but not the same kind as that of the asparagus.

"Nature of the Rust.—The asparagus rust is due to a fungus (*Puccinia asparagi* D. C.), that is, a minute plant consisting of microscopic threads which grow through the substance of the asparagus plant, taking up the nourishment that is needed, and finally breaks through the surface to bear the innumerable brown spores that give the dark color to the spots on the asparagus skins. This is the last stage in the development of the rust fungus, and as such remains over the winter. When the warm, moist weather of spring and summer comes, the spores above mentioned germinate, and a new lot of asparagus plants may become infested.

"Treatment of Infested Fields.—There are two general methods of checking the rust, namely, by destroying the spores and by preventing their growing upon and getting a foothold in the substance of healthy asparagus plants. The rust fungi are among the most difficult to check—by protecting the plants they feed upon—by means of fungicides, Bordeaux mixtures, etc., sprayed upon them during the growing-season. While something may be hoped for with the spraying pump in July and August, the chief method of eradication lies in the destruction of the spores this fall. This can be done in a very simple and effective manner by carefully gathering all the parts of the asparagus plants that are above ground and burning them. It would be a waste of time to stack the tops and leave them to natural decay, and to place them in manure heaps would be still worse. The only safe thing to do when a serious enemy like this is in the asparagus field is to burn the plants even to the last scrap that can be gathered up. Let this be done at once, for any delay means the breaking up of the brittle, rusty plants and a generous sowing of the spores upon the ground. If the fire could go over the whole field and burn all the small as well as the large pieces, that would be the best of all.

"This autumn burning should be done by every asparagus grower, even if the rust is not yet seen by him. This enemy may become very serious if thorough measures are not taken at once and by all who are engaged in asparagus culture

"To those who may wish to add to the burning process the spraying of the summer-growing plants—not the spring shoots for market—the Station will have something to recommend later on, but the only thing to do now is to burn the 'bushes.' Instead of 'Arbor Day,' let it be a *smoke day* for the whole State, or wherever there is an asparagus patch.

"BYRON D. HALSTED, *Botanist.*"

"New Brunswick, New Jersey, September 18th, 1896."

Since the issuance of the circular, correspondence has been held with a large number of the botanists and horticulturists in Experiment Stations and elsewhere in the United States, with the result that

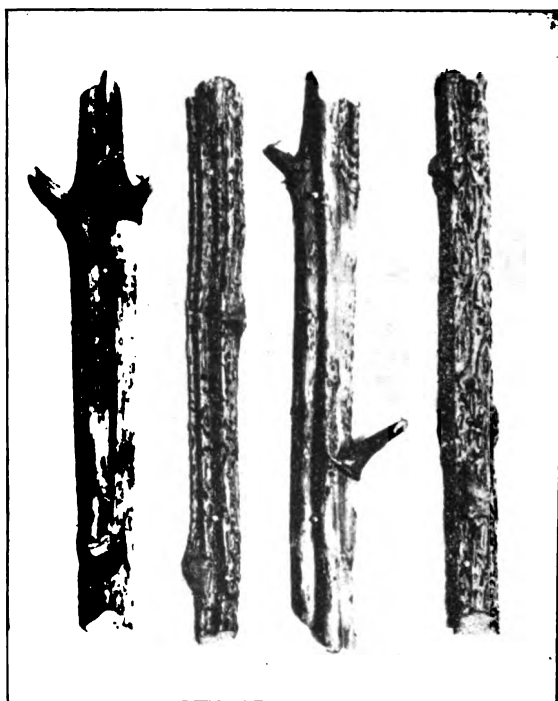


Fig. 54.
Portion of Rusted Asparagus Stems, Natural size.





Fig. 53.
Three Asparagus Plants with their Tops Killed by the Rust,

thus far the rust has been reported from New England generally, Long Island and Delaware. A personal examination has been made in our State, and the rust is abundant in all localities that have been visited. No one from the Middle, Prairie or Western Coast States reports the presence of the trouble, and from this it would appear that, at present, the rust of the asparagus is confined to the Atlantic Coast States north of Virginia.

The large growers in South Carolina became much interested in the outbreak, and asked for specimens of the rust, which were sent them, with the precaution that they were all thoroughly poisoned by soaking the blistered stems in a full strength of corrosive sublimate. Specimens afterwards received from the South all showed no signs of the rust. It is interesting to note that the same growers, although assured that they did not probably have the rust, at once concluded to burn their brush, as recommended in the above circular, and thus run as small a risk as possible of having their fields injured by the new enemy that has come so suddenly upon the Northern asparagus fields.

In looking up the history of this *Puccinia asparagi* D. C., only one publication of its having been found in the United States is thus far discovered, namely, in February, 1880, in the "Catalogue of the Pacific Coast Fungi," by Drs. Harkness and Moore. In a recent letter received from Dr. Harkness, he kindly informs me that the rust was found near Sacramento, and regrets that no specimens were preserved. This was over a quarter of a century ago, and it is strange that it has not been collected since that date. It seems to be the fact that the cryptogamic herbaria of the country were without a specimen of the asparagus rust until the present outbreak.

The writer has never met with any species of rust that was so overwhelming in its attack. Fields, for example, of a dozen acres would not have a plant and scarcely a square inch of surface, free from the pustules. It attacks all ages of plants, but the older beds turned brown first, and the last to lose their usual green color were the seedlings. Figure 53 will give the reader an idea of a fair sample of rusted plants. The brush is reduced to the main stems, the finer portions having become thoroughly affected and fallen away. Portions of stems of older plants are shown in Figure 54, where the rifts in the skin may be seen and the spore masses appear as dark blotches.

All the varieties of asparagus seem to be equally susceptible to the

rust, with the exception of the "Palmetto." An examination of several fields of this variety, sometimes growing alongside of other sorts, leads to the opinion that upon a basis of one hundred the "Palmetto" would give a percentage of sixty for rustiness.

When once seen the rust is not easily mistaken for any other disease. There are, however, two fungous troubles of the asparagus that have been misleading. One of these causes brown spots that are nearly circular upon the stems, suggesting, along with the yellow of the surrounding surface, the coat of the leopard. The second is an anthracnose (*Colletotrichum* sp.) and produces multitudes of minute dark specks upon the stems. The appearance of this latter and by no means insignificant pest is shown in Figure 55. It develops later in the season than the rust, and is much finer in its growth in every way.

NASTURTIIUM BLIGHT.

From several quarters complaints have come of a blight of the nasturtium. While the plants are quite small, and before the foliage is half the normal size, the leaves will show discolored spots which at first are "watery" in appearance, but soon become blotched with brown. These patches appear without any order and are of all sizes and shapes.

Figure 56, made from a sun-print of two leaves, indicates fairly well the general appearance of this nasturtium blight. This is quite similar to the bacterial blight of beans, and a microscopic examination of the germs suggests that the organism may be the same. One of the worst cases of this blight of the nasturtium was upon plants that were growing within a few feet of a field of beans badly affected with the bacterial blight.

No attempts have been made to check this blight, but from its nature it is quite probably amenable to treatment. Experiments with beans during the past season show good results with the bacterial disease of beans, and therefore it may be presumed that the ordinary fungicides will prove effective with this enemy of the nasturtium.

AN AMPELOPSIS BLIGHT.

The very popular ivy, *Ampelopsis Veitchii*, is a victim to a serious leaf blight, the appearance of which is shown in Figure 57.*

* From the "American Florist" for August 1st, 1896.



Fig. 55.
The Asparagus Anthracnose.

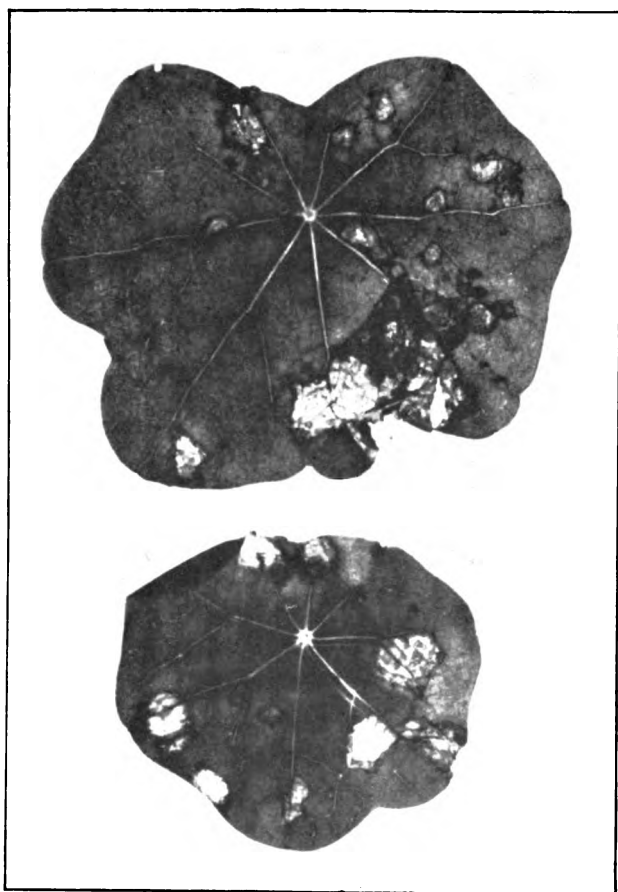


Fig. 56.
***Nasturtium* Bacterial Blight.**

The fungus (*Phyllosticta ampelopsidis* E. & M.) is one of a large genus, many members of which are called "leaf spots," while others take the more general name of "blight."

The fungus makes its entrance into the leaf from the surface, and by spreading, causes a small spot at first of pale green, but later on it enlarges and becomes brown. The spores are produced in small

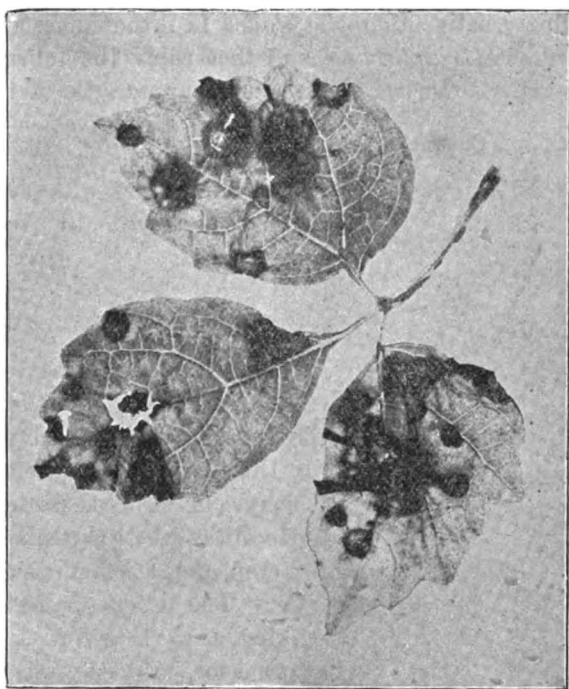


Fig. 57.

The Ampelopsis Blight.

dark pimples that may be found scattered over the surface of the dead portions of the leaf. From these pimples the spores ooze out and are scattered to other leaves, and thus the blight spreads with considerable rapidity.

It is not difficult to conceive of this blight increasing to an alarming extent, in which case one of the most useful and beautiful of our ornamental plants would require painstaking treatment. There is no

reason, from the nature of the fungus, why this enemy might not be controlled by the proper use of fungicides. The spraying should be done in the same way as for grapevines, which are closely related to the Boston or Japanese ivy and have similar pests to the one here considered.

ANTHRACNOSE OF MAGNOLIA.

The ordinary native *Magnolia glauca* L. is sometimes affected with an anthracnose (*Colletotrichum* sp.) that ruins the foliage and also kills the smaller branches. The general appearance of the anthracnose upon the leaves is shown in Figure 58, where a single leaf is shown half its natural size, with several patches entirely destroyed by the parasitic fungus.



Fig. 58.
Anthracnose of Magnolia.

THE CHESTNUT BLIGHT.

Several complaints have been made to the Station of a blight upon the chestnuts, and particularly those varieties that have been developed in the nursery. A visit was made to some of the localities where chestnuts are grown as a crop, and also to nurseries of young trees. The blight is certainly very striking, as the trees turn to a decidedly brown color, due to the foliage becoming spotted. The appearance of the blighted foliage is shown in Figure 59, made from a sun-print of two diseased leaves. The fungus *Marsonia ochroleuca* B. & C. causes a remarkable spotting of the foliage, and greatly interferes with the work of the leaves.

While no experiments have been carried out, there is no reason why this leaf parasite may not be controlled by the use of fungicides, applied in the same way as for orchards.

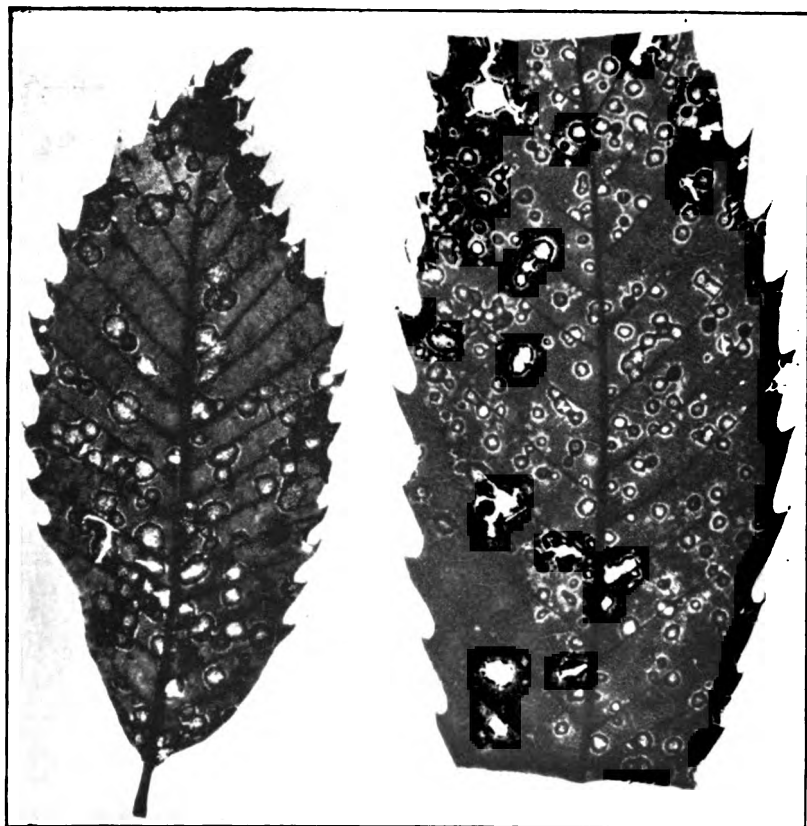


Fig. 59.
Chestnut Leaves badly Blighted.

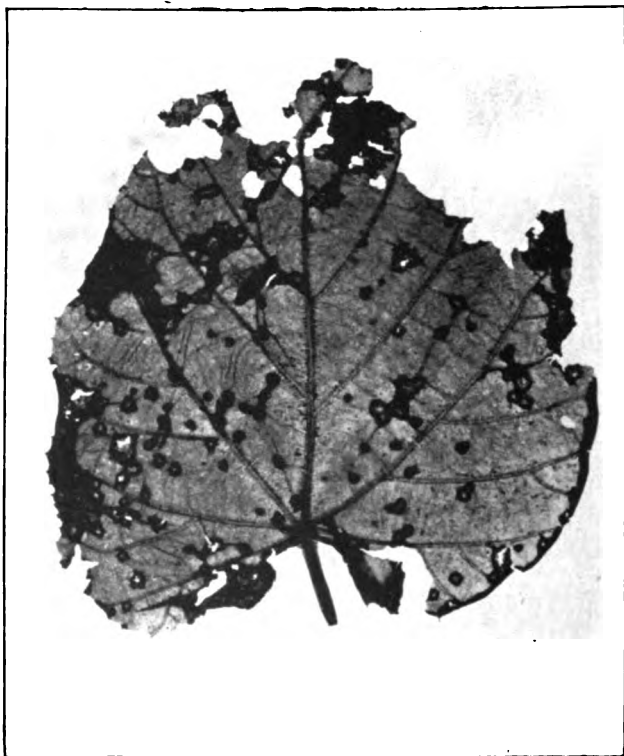


Fig. 60.
The Leaf Blight of the Linden.

A BLIGHT OF THE LINDEN.

A leaf-spotting of the linden or basswood has been met with this year that is quite destructive to the foliage. Figure 60 shows a leaf that is badly spotted. This is due to the *Ceroospora microsora* Sacc., and from the nature of the parasite it should yield to spraying with fungicides.

EXPERIMENTS WITH PEACH ROOT GALLS.

There have been many complaints of the galls upon the roots of peach trees in the State, and some work has been done upon the subject during the past season. In the last report (1895), pages 359, 360, a brief mention was made of the trouble, and an engraving published showing two specimens of the peach root gall.

Peach pits, originally Southern growth, were obtained from a nurseryman in the State, and the seeds, then beginning to germinate, were planted in the greenhouse upon the 15th of February. In one set of six large pots sand was used, and in a second parallel set common greenhouse earth was employed. Into two pots of each set raspberry galls were added after having been cut up into small pieces; two received minced peach galls and one received nothing. One of the two pots receiving the raspberry galls and the peach galls respectively had sulphur added at the rate of one pound to four hundred of soil.

The scheme stood as given below :

Sand.....	Raspberry galls. Raspberry galls.	Peach galls. Peach galls.	Check. Check.
Soil.....	Raspberry galls + sulphur. Raspberry galls + sulphur.	Peach galls + sulphur. Peach galls + sulphur.	

The seedlings were thinned out from time to time and the whole removed from the pots upon September 17th, after a period of seven months.

It was found that the pots, both sand and soil, in which the inoculation had been with minced peach knots, were much more diseased than elsewhere. There were some galls upon all the plants, but the least where no peach virus had been used. There was no difference between the check pots and the ones receiving the minced raspberry

galls. The sulphur showed unmistakable power for retarding the development of the galls. The soil pots showed a much larger development of the galls than those containing sand.

A considerable space in a bench was devoted to a duplicate of the above tests. In this instance the seedlings were grown in rows, and the minced raspberry and peach galls added to the soil in the rows before the seeds were dropped. In like manner the sulphur was added in the open row. Two sets of this experiment were made, separated by three weeks in time, but all harvested upon the same day (September 7th) as the pots above mentioned.

The results in the soil upon the bench were in all respects parallel with those in the pots, and point to the conclusion that the peach root gall is decidedly contagious, and with the seedlings surrounded with minced peach galls the affection is almost certain to appear, and in a violent form. Upon the other hand, the experiments do not indicate that the raspberry root galls (Figure 61), when treated in the same manner as the minced peach galls, have any power to induce the formation of knots upon the peach. All of the experiments show that sulphur may be looked to as a remedy for the trouble. Figure 62 shows three peach roots grown in pots, while Figure 63 gives the appearance of three others grown in soil in greenhouse beds. These are average specimens, and it is seen that they show results as stated in the above tentative conclusion.

A nurseryman was interested in the subject under investigation and kindly followed out a plan that was submitted for trial. A portion of his peach pits were treated to sulphur—one part to 250 of the soil, and another with one part of lime to 500 of the soil. A belt of several rows in the nursery was planted with the sulphured seedlings, and another to those receiving lime. This field was visited by the writer twice during the growing-season, and at both times the rows receiving the sulphur were easily distinguished by their larger size and greater vigor. No galls were found upon any roots except in the check rows. At the close of the second season these plants will be thoroughly examined and results may be then expected. So far as the test has gone, the owner expresses satisfaction with the treatment of peach seedlings with sulphur as a remedy for the peach root galls.

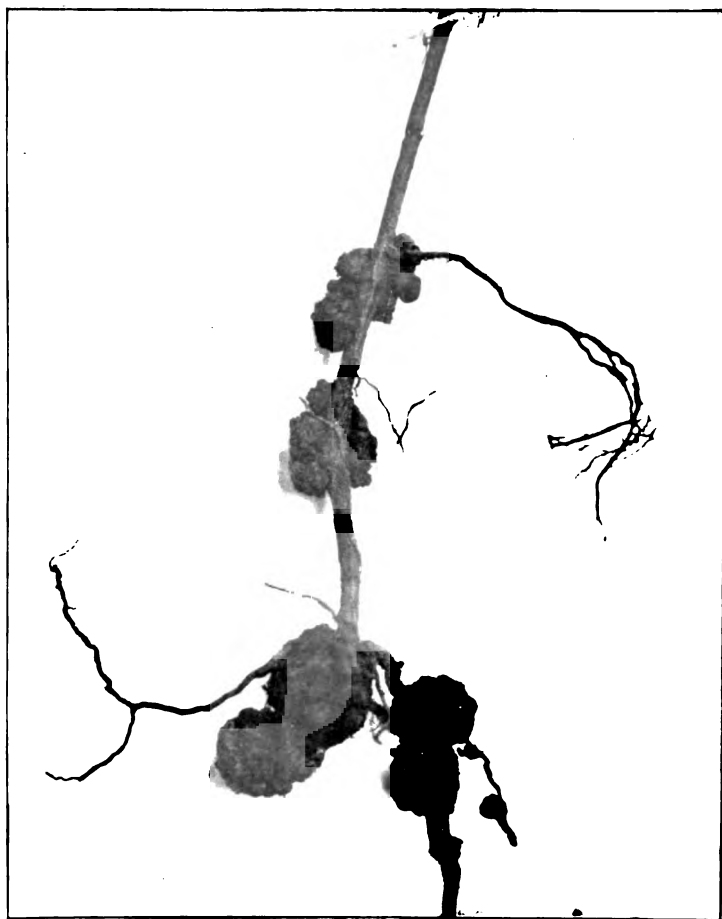


Fig. 61.
Root Galls of the Cultivated Raspberry.

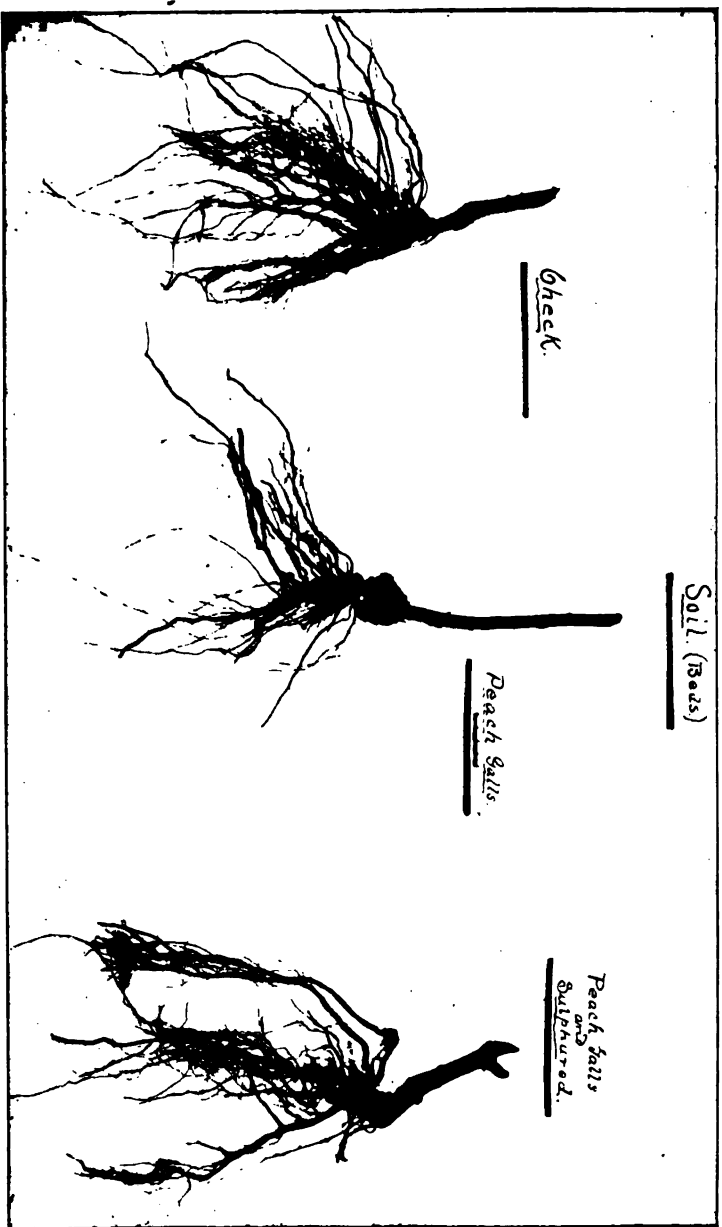


Fig. 63.

Seedling Peach Tree Roots, grown in the greenhouse, with mined Peach Galls, with and without Sulphur as a Check.



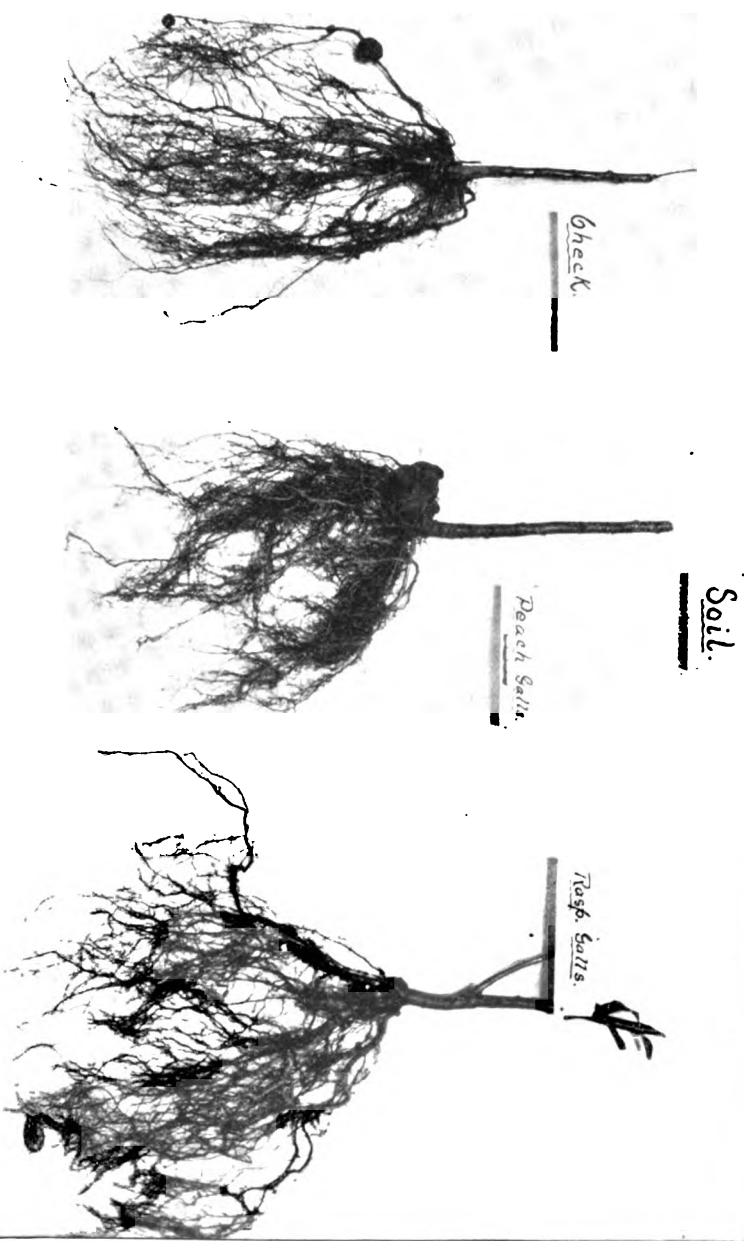


Fig. 68.
Seedling Peach Tree Roots, grown in the greenhouse, with minced Peach Galls, with and without Sulphur and a Check.

Siftings from Other Sources.

During the past year some notes have been made upon the bulletins of other Experiment Stations and published in "Science" from time to time. Some selections are here made from such notes with the thought that they may be of value to the crop-growers of New Jersey.

SOIL IRRIGATION.

A good deal is being done in the Experiment Stations in the application of water to soils for purposes of crop-growing.

From the last issue of the "Experiment Station Record" (Vol. 7, No. 6), under the head of agricultural engineering, particular mention is made of experiments in irrigation at the Utah Station. Under farm irrigation it is gathered that two feet of water is required for best results with grains upon clay soil, while a sandy soil needs three and a half feet. For wheat, clover and timothy the intervals between irrigation should be about twelve days. With spring wheat there was a decrease of yield when there were more than three waterings. Better results are obtained by day than by night irrigation. Fall watering favored timothy, but not winter wheat. The flooding system is superior to the method by furrows, and the acre-foot unit is recommended by Professor Mills for general adoption.

Under orchard and vineyard irrigation, Professor Richman holds to the opinion that the best plan is to apply the water but a few times, but supplying enough to reach the deeper roots of the trees. Young trees require more frequent watering than old ones, and the opinion is erroneous that water injures the trunks of trees even when confined around the base by heaped-up earth.

Among other bulletins cited is one (No. 25) from the Nevada Station, largely a compilation from publications of the Colorado and Wyoming Stations, etc., and deals with water-storage measurements, pumping, etc. Another is No. 6 of the Montana Station, upon measurements of water, giving value of water, water duties and tables for discharge over weirs. Several other items are given upon this general subject from Kansas and Washington.

There is a manifest growing interest in agricultural engineering, as it relates to the distribution of water over the soil.

While irrigation has been and will continue to be a leading feature

of agriculture in the arid regions of the West, there is little doubt that it will also increase in importance in the East. Field irrigation may not become a common practice along the Atlantic coast, but it seems likely that methods will be provided for supplying water to truck and berry fields when there is a shortage due to drought.

SOIL TREATMENT OF ORCHARDS FOR DROUGHT.

In many parts of our country crop-growing is very uncertain, due to a lack of sufficient rainfall. This fact has led the Nebraska Experiment Station to make a study of methods of mitigating the ill effects of dry weather. Professor Card, in "Some Obstacles to Successful Fruit-Growing," Bulletin 39, Nebraska Experimentation Station, reports results upon an old orchard, a third of which was mowed, a third pastured and the remaining third cultivated every two weeks. The trees in cultivated ground suffered much less from the drought and hot winds than those in sod, the foliage being more vigorous and without the wilting during the hot windy days common to the trees in the sod ground.

The fruit was larger and better upon the cultivated trees than elsewhere. An examination of the soil showed that for every 100 barrels of water in the first twenty inches of sod ground there were 140 barrels in the cultivated ground. The soil in all regions when drought is experienced needs a covering of mulch. It is not practicable to add a mulch of straw or other material, but the upper few inches of the soil when kept light and mellow serves as a mulch for all below. Therefore a key to the solution of the problem is to plow deep; even subsoiling will pay for some crops, and then mulch by means of a mellow layer upon the top produced by frequent cultivation.

DETASSELING CORN.

The removal of the male flowers from a large or small per cent. of the corn plants in a field has been experimented upon at various stations. Thus, in Maryland, where two-thirds of the tassels were removed the detasseled rows gave a decrease of nearly 10 per cent. At the Kansas Station by detasseling alternate rows of six varieties in every case there was a reduced yield averaging 22 per cent. Delaware obtained, under similar circumstances, an increase of 6.6 per cent.

Before us is the bulletin (No. 37) upon corn experiments of the Illinois Experiment Station, in which detasseling receives its share of consideration. "In eighteen out of twenty-three comparisons the yield of corn was greater for the rows (alternate) having the tassels removed. For tassels pulled we have an increase of 27 per cent. and for those cut only 6 per cent. Removed before expanding gives an increase of 11 per cent. The average increase is 13 per cent." At the Cornell Station one report (1890) was an increase of 50 per cent. for detasseling, but the next year there was no difference. The results thus far obtained teach that the end of experimentation in this direction is not yet reached.

PREVENTION OF SMUT IN OATS.

There is a large loss annually from smut in various crops, and the oat is a prominent sufferer. It was about 20 per cent. at the farm of the Ohio Station, and a fair estimate of loss for the whole United States is more than \$18,000,000 annually.

This smutting of the grain, it has long been known, is due to an invading fungus that produces vast multitudes of spores in the grains; in short, the grains are transformed or replaced by the fungus, which in its final condition is mostly spores, usually dark and dusty.

Professor Selby shows by his experiments that the smut enters the seedling oat plant by spores adhering to the seed grain and may be prevented by the destruction of the spores attached to the oats before sowing. This may be done by immersing the oats in hot water at a temperature of 133° F. for fifteen minutes. This treatment likewise increases the vigor of the seed. It was also found that "soaking the seed for twenty-four hours in a three-quarter per cent. solution of potassium sulphide, made by dissolving 1½ pounds of the salt in 25 gallons of water, is equally efficient in smut prevention." But the above methods of treatment apply to wheat, barley and other grains, with certain modifications to suit the particular cases.

MUSCARDINE DISEASE OF CHINCH-BUGS.

One of the most serious of insect depredations to wheat and corn is that caused by the chinch-bug, and for years methods of checking it by employing a parasitic fungus have been the subject of research. In Kansas special appropriations have been made by the Legislature

to determine the best means of propagating and applying the virus. The latest information upon this subject comes in the shape of a sixty-page bulletin with eight plates (No. 38, March, 1895) from the Illinois Experiment Station, prepared by Dr. Forbes. The fungus experimented with is *Sporotrichium globuliferum* Speg., which was cultivated successfully upon a mixture of corn meal and beef broth, and afterwards distributed to farmers in the chinch-bug infested portions of the State.

The white muscardine (*Sporotrichium*) spreads most rapidly in the field when the weather is moist and the "catch" is quickest, in the low spots in the field and among fallen herbage. Professor Forbes is of the opinion that the disease may be developed without infection by artificially producing the above conditions by trampling down the grain in spots or cutting and stooking small portions as starting-points for the infection. It was observed that mites feed upon the muscardine, and in some of the artificial cultures eat up "the last vestige of the fungus." The *Sporotrichium* lives upon many kinds of insects, and a plate is given of the appearance of it upon the leaf skeletonizer (*Carnarsia*), June beetle (*Lachnosterna*), and walnut caterpillar (*Datana*).

BACTERIOSIS OF RUTABAGAS.

The number of diseases of plants of bacterial origin is rapidly on the increase, or, more strictly writing, the nature of these troubles is in these later days being better understood. A portion of Bulletin 27 of the Iowa Experiment Station is devoted to a disease of rutabagas that Professor Pammel finds, through a long course of bacteriological study, to be caused by a micro-organism which he names *Bacillus campestris* n. sp., and figures in details in a plate. This disease is distinguished by its strong odor, the decay usually beginning at the crown of the root, the fibro-vascular zone turns black, while the softer portions of the root become soft and finally watery. Healthy roots were caused to decay by introducing the bacilli, previously isolated by cultural methods, into their tissue.

POTATO CULTURE.

Within a month no less than six bulletins have been issued by as many stations upon potato culture or some phase of it.

Hastening Maturity of Potatoes.

"Hastening Maturity" is the sub-title of the one (No. 36) from the Rhode Island Station. Three methods of bringing about an earlier crop are considered, and one in detail, as it has been tested at the station. Director Flagg and Mr. Tucker write: "Maturity may be hastened in three ways—(a) By planting sets in pots in a greenhouse and transplanting to open ground; (b) by sprouting, that is, planting sets thickly in a cold frame and when ready to break ground transplanting them to the field, and (c) by budding." For the latter, small potatoes the size of hen's eggs are given heat and light for six weeks or so before planting time, thus causing a strong bud to develop and roots to form. The budded potatoes are placed in the field with the care given to onion sets, etc. A gain of 32 bushels per acre was obtained by this method over the ordinary way of planting.

Crimson Clover Good for Potatoes.

In Bulletin No. 38 of the Maryland Station, Director Miller and Mr. Brinkley find that crimson clover plowed under increased the yield, in 1894, 36, and in 1895, 50 per cent. Ridge and level culture proved of equal value, and also deep and shallow cultivation showed no difference. Spraying four times with Bordeaux mixture to prevent blight doubled the crop.

Potash for Potatoes.

At the Kentucky Station (Bulletin No. 61) Director Scovell found that potash was the most profitable commercial fertilizer to use, while the nitrates and phosphates were sometimes used at a financial loss. Several tests were made to check the scab; but here is an instance in which it is a misfortune for the enemy to fail to appear anywhere in the field, and the results are postponed thereby.

Variety-Testing of Potatoes.

Bulletin 65, Ohio Station, is devoted to the comparison of varieties of potatoes and experiments with fertilizers, by Professors Green and McFadden. They maintain that variety trials are of much value only when the sorts are tested under several sets of conditions. It is the summing up of sets of trials that brings the results of practical

importance. Thus the three varieties that have averaged highest at the central and both sub-stations in Ohio are American Wonder, Columbus and Irish Daisy. Varieties that are the least influenced by variations of soil, climate, etc., they claim are the most valuable.

Scab and Internal Brown Rot.

Professor Green, in the Minnesota Station Bulletin No. 45, reports that the subsoiling of heavy clay land increases somewhat the yield of potatoes. Considerable space is given, with engravings, to the report upon treatment for scab. The germ theory, or fungous nature of the disease, is recognized in full, for it is stated that: "Perfectly clean seed planted on land which is free from scab fungus will always and in any season produce a crop of smooth, clean potatoes, no matter what the character of the land. * * * Land infected by the germs of this disease will produce a more or less scabby crop, no matter how clean and smooth the seed is." It is recommended to dig scabby potatoes as soon as ripe, because the scab continues to grow so long as the potatoes are in the ground.

The internal brown rot works at the center of the potato, and all thus infested should be discarded as seed. The cause of this trouble is not given.

Early and Late Potato Blights.

Bulletin 113 of the Cornell, N. Y., Station, treats only of the diseases of the potato, giving several illustrations of these troubles and one colorotype plate of blight. Two leaves are shown in this, one of the "early blight," and the other of the "late blight." The former is due to the fungus *Macrosporium Solani* E. & M., and the latter to *Phytophthora infestans* De By., a downy mildew which, when affecting the tubers, produced the potato rot—an old enemy in Europe, where it has caused famines, as in Ireland in 1846. Professor Lodeman draws largely upon the literature of this blight, mentioning its rapid growth in and destruction of the attacked vines, and the disagreeable odor of the ruined potatoes. The germ tube from the spore secretes a ferment that dissolves the cell-wall of the host, and permits the parasite to pass through. The term "late blight" came from the fact that the *Phytophthora* does not usually appear before August. The early blight comes sooner in the season, and usually the fungus follows after some injury, frequently the

work of flea beetles. The earlier plantings of the same variety are the more affected by this blight.

Bordeaux is a satisfactory remedy for the late blight, and a promising one for the early blight.

The cause of the scab is considered and corrosive sublimate highly recommended, with the precaution that it be not used so strong as to injure the seed.

The Potato Scab.

Several Experiment Stations are making tests of various substances for the potato scab. This trouble of the potato is due to a fungus closely related to the bacteria.

Bulletin No. 33 of the Rhode Island Station gives a somewhat lengthy report of experiments that cover three years, with various chemicals. Dr. Wheeler and Mr. Tucker, the authors, state that air-slaked lime, wood ashes and calcium carbonate, calcium acetate and oxalate all increase the scab, while calcium chloride prevents it, but likewise injures the potato plant. Calcium sulphate (land plaster) is the only form of lime not harmful to the potato and fails to increase the scab. Common salt reduces the amount of scab, and this explains why seaweed is healthful to potato land when used for manure. Barnyard manure increases the scab, probably because alkaline. On the other hand, oxalic acid tends to reduce the scab. It is thought that anything which increases the acidity of the soil will reduce the scab. The scab fungus seems to multiply in the soil when the potato crop is not present. Upon acid soils practical immunity from scab has been secured for three years. Potatoes free from scab may be grown upon acid land if no barnyard manure is used.

Potato Diseases Upon Long Island.

Mr. F. C. Stewart has made a study of potato diseases, the results of which appear in Bulletin No. 101 of the New York Station. In addition to the good results following from spraying with the Bordeaux mixture for the blights, notes are given upon an internal browning of potatoes, the cause of which is not determined. The brown spots are entirely surrounded by healthy tissue, and cultures made from the discolored portions produced no growth. Under the microscope the brown spots give no clue as to the cause of the trouble, and it would seem to be physiological and not mycological in its origin. Field experiments indicate that the browning is not transmitted from

seed to product, but the discolored tubers are not the best to use for planting. There are several stem blights of potatoes, but Mr. Stewart finds another which seems to strangle the plant, and working internally, will be a difficult one to check. A new *Fusarium* (*F. acummatum* E. & E.) is reported.

Government Farmers' Bulletin Upon Potatoes.

In addition to the above station bulletins, the United States Department of Agriculture has issued a farmers' bulletin (No. 35) upon "Potato Culture," by Mr. Dugger, with the following subheads: Soil and rotation, manuring, varieties, planting, change of seed, size of seed pieces, distance in the row, mulching, storing, with a lengthy summary. This is a remarkably comprehensive, condensed and clear exposition of potato culture.

The impression at least is gained from the above notes that the potato is fully recognized by experimenters as a leading crop in the country and likewise a subject that is many-sided and as yet far too little understood.

TREATMENT OF PEACH ROT AND APPLE SCAB.

Delaware is a small State, but large in its peach industry. The leading enemy to the peach crop, the fruit rot, naturally is a subject that demands the attention of the Station Mycologist, Prof. F. D. Chester. For several years he has been testing various fungicides for the rotting of the fruit, and the last bulletin (No. 29), recently issued, gives both the results of the experiments and general directions for spraying. It is recommended to remove and burn all dried or mummified fruit from the peach trees in winter and spraying the trees in early spring with bluestone solution. When the fruit buds begin to swell, spray with the Bordeaux mixture, and again just before the buds open. Spray again with Bordeaux when the bloom is falling, and add a little Paris green to keep off the curculio. About two weeks later the same treatment is repeated. As the Bordeaux coats the fruit with the lime mixture, for the last two sprayings copper acetate, a colorless solution, is employed. A tenfold increase of sound fruit was obtained by this process at a cost of about twelve cents per tree.

The treatment for apple scab was the Bordeaux mixture, to which London purple had been added, and applied five times to the trees. The good fruit was doubled by this treatment, while the general health of the apple trees was much improved.

PLUM LEAF SPOT.

The camera and photo-engraving process are doing wonders for the Experiment Station bulletins. No. 98 of the New York (Geneva) Experiment Station contains five full-page process plates upon the plum leaf spot. The results of a comparative study of the value of Bordeaux mixture and Eau Celeste soap mixture are given. The Bordeaux is preferable, and the first spraying should be made soon after the bloom falls. The same treatment also lessens the attack of fruit rot. The reader needs to see the plates to be impressed with the efficiency of the sprayings, for the loss is reduced from 86.5 per cent. to 17 per cent.

In similar spraying for the leaf spot of cherry no good results are obtained. But one swallow does not make a summer and one trial is not sufficient to condemn any spraying mixture.

BACTERIOSIS OF CARNATIONS.

Bacteriosis is a term now growing into general use for the diseases in plants due to bacteria. There are several of these troubles caused by micro-organisms, but none more interesting to the mycologist than that of the carnation. Dr. Arthur and Professor Bolley conjointly have issued the results of their studies in a neat bulletin (No. 59) from the Indiana Experiment Station.

This bacteriosis is widespread among carnations, and, while seated in the leaves, checks the growth of the whole plant. The disease germs enter the plant through the stomates, punctures of insects or by dissolving a passageway in the cellulose through the action of an enzym. The methods of isolating the germs of the *Bacterium Dianthi* Arth. & Boll. n. sp. are given and a full-page heliotype plate is presented of gelatine tubes and another of the appearance of a portion of a diseased plant. It is found that any variety of carnation may be affected, but weak and old plants are most susceptible. Other than members of the pink family of plants are exempt from this trouble.

Valuable practical methods of culture to prevent the bacteriosis have been found, the chief ones residing in the fact that the disease is favored by moisture. By keeping the foliage dry, by watering the soil between rows of wire netting arranged to support the plants, the disease is largely prevented. The aphid should be kept off.

COMBATING CARNATION RUST.

The growing of carnations is a large industry in this country, but is beset with many vicissitudes, not among the least of which is the carnation rust. This trouble has been under investigation at some of the Experiment Stations, and before us lies Bulletin No. 100 of the New York Experiment Station, with the title as given above. Mr. Stewart, the author, has tested the germination of the spores of the rust fungus in various substances, and finds, for example, that a 1 to 100 solution of copper sulphate is much too weak to prevent germination. When common salt is used, 1 to 45 is the strongest solution in which the spores can grow. The spores, on the other hand, are remarkably susceptible to the action of potassium sulphide, a 1 to 3,000 solution entirely preventing germination. A similar series of results was obtained by soaking cuttings in the above solutions, those in potassium sulphide being unharmed. Attempts to cure rusty plants by spraying with fungicides failed, but good results were obtained in preventing its appearance upon healthy plants. Rust, it has been shown, will spread among mature plants. It is important that carnation plants be held up from the ground by inverted V's of wire netting. For unknown reasons, some varieties are much more susceptible than others to the rust.

DAMPING OFF.

Professor Atkinson, in Bulletin No. 94 of the Cornell Station, reports at length upon a study of microscopic fungi that work upon seedling plants in greenhouses and destroy them by what is commonly known as "damping off." This fatal result is occasioned by great moisture content of the soil, high temperatures, close rooms and insufficient light—all of which favor the growth of the low forms of fungi causing the destruction of the stems of the seedling. The conditions above given should be as far as possible eliminated. As the moulds, etc., enter the plants from the soil it is evident that the latter should be as free as may be of the germs. Diseased plants need to be thrown away and, in serious cases, the soil likewise. The soil may be sterilized by steam heating before the seeds are sown. Those who would have healthy greenhouse plants must be wise as mycologists and as loving as mothers.

RECENT APPLE FAILURES.

In another bulletin (No. 84) from the Cornell Experiment Station—and there are many and fine ones—the recent apple failures of western New York are considered by Professor Bailey. A glance at the cuts shows that failures may be due to imperfect pollination, injudicious application of fungicides, but more particularly to the ravages of the apple scab (*Fusicladium dendriticum* Fl.), of which Professor Bailey gives a full-page colored plate, showing the scab enemy in detail from the appearance of the young distorted fruit to the microscopic structure of the fungus shown in leaf sections. That the scab fungus is the leading cause of apple failures is demonstrated by the fact that thorough spraying to check it has brought productiveness. The essentials for success in apple culture, as given by the author as his concise summary, are “till, feed, prune, spray.”

BLACK KNOT OF PLUMS AND CHERRIES.

The black knot fungus (*Plowrightia morbosa* Schw.) is an old orchard enemy. Professor Lodeman, in Bulletin 81 (December, 1894), Cornell Experiment Station, has given the long bibliography of the subject and shows, by means of cuts, how the spores of the fungus may find their way between the adjoining layers of bark in the forks of the small limbs. At these places the bark is thin and the growing layer (cambium) comes near to the surface, thus facilitating the inoculation. Lodgment is also produced at these angles between stems, and besides it is here that knots are most apt to form. Experiments in spraying knotty trees with Bordeaux mixture gave results that were decidedly encouraging.

ARTIFICIAL POLLINATION OF SQUASHES.

Mr. L. C. Corbitt, in his bulletin (No. 42, South Dakota Experiment Station) upon squashes, observes that in Dakota there is an abundant production of flowers of the squash plants, but “an almost complete failure of fruit.” For two years he has been experimenting to find the cause, and concludes that the failure is due to an absence of insects capable of transferring the pollen from the male to the female flowers. In their absence it is further demonstrated that

profitable crops of squashes can be grown by resorting to artificial pollination. This pollination is best effected in the early morning, and consists in touching the stamens of a male flower, picked off and held in the hand to the large fleshy stigmas of the pistillate flowers, which are, of course, left on the vines. It was found that 62 per cent. of the flowers thus treated produced fruit, while practically none will grow if left dependent upon nature for the transfer of the pollen.

THE AMERICAN PERSIMMON.

A station bulletin (No. 60, Indiana) has been issued upon the persimmon, and with several full-page plates of the tree and its fruit, the subject is given a most favorable introduction. Professor Troop shows that on account of the astringent principle in the unripe fruit, the tendency of the plant to sucker, and the long time before the tree comes into bearing, the plant has been neglected. By new methods of cultivation trees may begin to bear "in three to five years from the bud or graft," and the fruit is capable of much improvement and very likely will equal the Japanese sorts, which are considered choice delicacies by many.

Under methods of propagation it is stated that, like the apple and many other standard fruits, the persimmon does not come true by seed, and therefore a variety needs to be continued by the ordinary methods, namely, by budding or grafting either of the stem or root. A plate is given showing a "top-worked" old tree, and by grafting, the comparatively worthless tree was made to bear a fine variety of persimmon.

When we bear in mind the revolution in grape culture in this country due to thorough work upon our native members of the genus *Vitis*, any similar study of another fruit group is welcome, fraught as it is with the possibility of adding a new fruit of no doubtful merit to our lengthening list.

ELECTRO-HORTICULTURE.

The latest results drawn from experiments with electric light upon vegetation are by Professor Rane in Bulletin No. 37 of the West Virginia Experiment Station. Investigations along this general line began in 1861, when Herve-Mango demonstrated that electric light can cause the formation of green material (chlorophyll) in plants and

produce other phenomena, as turning toward the light (heliotropism). Prilleaux, in 1869, showed that assimilation in plants goes on in the presence of artificial light. Dr. Siemens experimented largely with arc lights, both within and at other times outside of and above the plant-houses. Professor Bailey, who at Cornell University has tested electric lighting extensively during the past few years, in reviewing Dr. Siemens' work, writes: "He used the term electro-horticulture to designate this new application of electric energy. He anticipated that in the future the horticulturist will have the means of making himself practically independent of solar light for producing a high quality of fruit at all seasons of the year. * * * Whatever may be the value of electric light to horticulture, the practical value of Siemens' experiment is still great." After years of trial, Professor Bailey stated in one of his reports: "I am convinced that the electric light can be used to advantage in the forcing of some plants."

In the fall of 1892 Professor Rane introduced the use of the incandescent light in place of the arc lamp, and his recent report, with its illustrations from photographs of plants, etc., has features of interest to all who are interested in science as well as the market-gardener. He finds that "the incandescent electric light has a marked effect upon greenhouse plants," it being "beneficial to some plants grown for foliage, such as lettuce. Flowering plants blossomed earlier and continued in bloom longer under the light" than elsewhere. Plants like spinach and endive "quickly ran to seed, which is objectionable in forcing these plants for sale. Most plants tended toward a taller growth under the light." The fact of plants responding promptly to electric light is widely demonstrated, but that it will be an economical method of growing crops is not so clearly shown.

SUB-IRRIGATION IN THE GREENHOUSE.

The Ohio Experiment Station is taking a lead in the study of irrigation under glass, by Prof. W. J. Green. In a recent bulletin the construction of the greenhouse with iron frames and bench-tiles is fully shown by engravings, as also the great difference in the size of lettuce grown with sub-irrigation and surface-watering, it being twice as large with the former as the latter method. The idea of irrigating below the surface grew out of an attempt to prevent the rotting of lettuce by not wetting the foliage. Sub-irrigation is cheaper

than the old method of surface-watering; the soil remains in a better condition, and the plants are less liable to decay. These results come largely from the soil, permitting the air to pass freely through it, besides supplying water constantly to the roots.

PLANTS THAT LOOK LIKE THE RUSSIAN THISTLE.

In Bulletin No. 39 of the Illinois Experiment Station, Mr. Clinton, the Assistant Botanist, brings out by means of text and engravings, some of the plant rogues that resemble the Russian thistle.

Among those of special mention are the winged pigweed (*Cycloloma atriplicifolium* (Spreng.) Coult.), one of the plants of the plains. It is easily distinguished from the Russian thistle by its flat leaves of the ordinary sort. In the autumn this plant, by breaking away from the soil at the root, becomes one of the noted "tumble weeds." Another species of weed quite closely related to the last, and likewise a "tumbler," is the *Amarantus albus* L. It is not confined to the West, but may be found in many an Eastern neglected field. This amaranth has a first cousin that is spinose (*A. spinosus* L.), and for this reason is easily mistaken for the Russian pest. Somewhat more remote as regards botanical relationship is the horse nettle (*Solanum Carolinense* L.), which is akin to the tomato, egg-plant and potato. It has yellow prickles and berries. The Texan horse nettle or "sand bur" is even worse than the last, to which it is closely related. It is *Solanum rostratum* Dun. Of course it would be a fault of omission not to mention the Canada thistle in this connection, as it is one of the most despised of the prickly weeds. There is a prickly lettuce (*Lactuca Scariola* L.), common in the West, that resembles the Russian intruder, but easily distinguished from it by the flat leaves, which are polar, and the species is a compass plant.

WEED SEEDS IN WINTER WINDS.

It is well known that winds play an important role in the distribution of seeds. Professor Bolley, in the North Dakota Experiment Station Bulletin No. 17 (March, 1895), records that in two square feet of a three-weeks-old and three-inch-deep snow drift upon an ice pond ten yards from any weeds he found 19 weed seeds, and in

another drift quite similarly situated 32 seeds, representing 9 kinds of weeds. While the wind was blowing twenty miles per hour a peck of mixed seeds was poured upon the snow crust, and ten minutes after, 191 wheat grains, 53 flax seeds, 43 buckwheat and 91 ragweed seeds were found in a trench 30 rods from where they had been poured upon the crust.

LEGISLATION AGAINST WEEDS.

The Division of Botany, United States Department of Agriculture, has issued a bulletin (No. 17), prepared by Mr. L. H. Dewey, "in response to a growing demand among agriculturists and legislators for data which will enable them to prepare laws better adapted for the control of weeds than those now in use." One per cent. of increase in the crops, which might be obtained by weed destruction without much cost, would amount to \$17,000,000. The passage of proper laws against weeds is important and should be effected with dispatch.

The weed laws are listed as found upon the statute-books of the following States: Arizona, California, Connecticut, Delaware, Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Michigan, Minnesota, Missouri, Nebraska, New Jersey, New York, North Dakota, Ohio, Oregon, Pennsylvania, South Dakota, Vermont, Washington, West Virginia, Wisconsin. Thus twenty-five States and Territories have laws against weeds. In some States the law is to suppress but a single species, as against Canada thistle in California, Delaware, Kentucky, while other States proscribe fourteen, as in Minnesota and Ohio. The largest proscription is with the Canada thistle, twenty-one out of twenty-five States. Six States legislate against the Russian thistle.

That there is no federal law against weeds is probably due to the fact that no one species is national in importance, but the Russian thistle may become such if it spreads as it is feared.

The basis for a general weed law is given, and includes as a leading feature a commission of which the State Botanist shall be the head. It is very important that new weeds shall be recognized and measures taken to eradicate them at once. Legislation for the purity of seeds will do much to check the introduction of weeds as foul stuff in commercial seeds.

REPORT OF THE ENTOMOLOGIST.

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REPORT OF THE ENTOMOLOGIST.

JOHN B. SMITH, SC.D.

General Review.

The intended work of this department for the season of 1896 was seriously modified by the San José scale investigation, which necessitated a trip to California and other Pacific Coast States during May and June, the season when, as a rule, a large number of complaints of insect injury are received. The results of that trip are stated in another portion of the report, to which reference should be had in this connection. It will suffice to say here that the present status of the scale in California was carefully studied, that the natural enemies which keep it in bounds there were ascertained; as were also the circumstances enabling these checks to become effective. Of the progress of the scale in New Jersey not much can be said at the present time. No new infested districts have been discovered, but in the infested regions heretofore known, new orchards have been found with more or less of the scale present.

The main feature of the present season in this connection has been the fact that the newly discovered points are generally such as have been infested from a distance, the scales having been carried by birds and insects to the new localities and not introduced on nursery stock. It has become increasingly probable that many orchards yet believed to be clear already have the scale, but to so slight an extent that it has not yet been noticed. In orchards known to be infested no great spread has been reported in most instances; but, on the other hand, several of the growers state that they have decreased in number as a result of their efforts, and in one or two cases entire extermination is claimed.

Perhaps the most marked occurrence during the year has been the appearance of the "army worm" in destructive numbers in different parts of the State. An account of this invasion will be found in a

subsequent part of the report. It need be said here, only, that New Jersey suffered very much less than either New York, Pennsylvania or Massachusetts, and as little as any point at which the "army worm" appeared during the present season. One curious feature was its very local appearance; in an entire county sometimes a single locality only was noted, and occasionally the outbreak would be limited to a single field. Furthermore, and oddly enough, it was not the same brood which was injurious in all parts of the State, but at different places they appeared at different times. The first notice of their occurrence was in May, when they were reported locally destructive in Monmouth county. Early in July they were reported from Bloomfield and Glen Ridge, in Essex county, and July 13th they appeared near Egg Harbor City, in Atlantic county. July 15th they were reported from Bloomsbury, in Hunterdon county, and lastly, early in September, complaint came from Englewood, in Bergen county. The amount of damage actually done by these insects was not very great; but the amount of alarm occasioned was sufficient to make quite a correspondence on the subject necessary.

A much more serious pest, which did a great deal more money damage, was the "melon louse." This appeared during the present season in all parts of the State where melons of any kind are grown, and in the Delaware counties the early crop was almost totally ruined. A bulletin on this subject will be prepared during the winter of 1896-97, so as to be ready for distribution in time to inform melon-growers for the season of 1897. It is possible to control the pest; but it requires very prompt action, and it is necessary to be prepared in advance in all respects when they make their appearance on the melon fields.

The Hessian fly, which was so seriously injurious in 1895, did very little damage indeed, in 1896. Most of the farmers either restricted their acreage of wheat to a considerable extent or had sown late the previous year; hence the circumstances were all against the insects, and a large measure of exemption was secured. It is not likely that next year will see any great increase, particularly if late sowing is again practiced.

A circular letter was sent in early July to all the crop correspondents in the northern part of the State, asking for information concerning the condition of wheat as regards the Hessian fly. The following replies were received:

July 2d, Mr. Wm. I. De Kay, Papakating, Sussex county, says: "There is but little wheat raised in this section. I know of but one or two pieces, and they have not been attacked by the Hessian fly."

July 3d, Mr. J. D. Vannatta, Rocksburg, Warren county, writes: "Will say that the Hessian fly has not done as much damage this summer as was anticipated; but last fall, in the early sowing, they destroyed some fields entirely, and they were plowed and sowed with oats this spring. Some other fields that were sowed late, say about the 10th of October, will yield a fair crop. Still, occasionally, a field of earlier sowing will yield an average crop while fields within half a mile of the former were destroyed. Owing to the ravages of last season there was less wheat sown than in former years, farmers sowing rye rather than risk the fly. * * * I think the fly will not bother us this fall if seeding is deferred until about the 1st of October. I am unable to give the proportion of grain injured, as in some fields it is entirely gone, while others may possibly yield the seed and still others may give ten bushels per acre."

July 3d, Frank Roe, Augusta, Sussex county, N. J.: "I have heard of no damage done to wheat in this locality by the Hessian fly the present season."

July 3d, Asher Fleming, Peapack, Somerset county: "In reply would say that the wheat crop is now being harvested, and I do not know of a single instance where the wheat crop has been injured by the Hessian fly in this vicinity."

July 6th, G. W. Van Horne, Fredon, Sussex county, N. J., writes: "I have made some inquiry among my neighbors with reference to the ravages of the Hessian fly. In only one instance was it thought that the wheat was injured in that way this year. Another, whose wheat failed to survive the winter, thought that the loss was due in part to injury by the Hessian fly soon after seeding."

July 8th, Jacob McCarty, Montague, Sussex county, N. J., wrote: "In reply will say that there is but little wheat grown in this locality, and that I have heard of no damage that can be traced to the Hessian fly and that none has come under my observation."

August 8th, Mr. Abram C. Holdrum, Westwood, Bergen county, N. J., writes: "Bergen county's crop of wheat is very small, and I find that the crop has not been damaged in this vicinity by the Hessian fly. The farmers say that the fly has not made its appearance here."

Late in the season a number of complaints came from Atlantic county of injury to strawberries from leaf rollers and from a root plant louse. The little leaf-roller caterpillars are more or less present each year, but circumstances seem to have combined this season to favor an abnormal increase, so that they became positively injurious. No measures were taken to check them, and when the complaints were made it was so late in the season that the caterpillars had completed their feeding and were ready to transform to moths, so nothing that would be practically useful could be recommended.

As to the root lice, these seem to have been unequally distributed and confined to comparatively a few fields, so far as my reports go. It was stated by those who complained of the insects that the purchase was infested by the same kind of lice, and, possibly, allowing the fields to become overrun with weeds may have had something to do with the trouble on the strawberry plants. It was impossible, at any rate, at the time when the letters were received, to make any personal investigations into the matter.

There has been less complaint of the strawberry weevil during the present season; but considerable damage has nevertheless been done in the southern parts of the State. No satisfactory measure for the destruction of this insect has yet been discovered, and the irregularity of its appearance, and the uncertainty whether in the coming season it will be troublesome or not, make the farmers loath to prepare until the beetle is actually present, and then it is too late.

Cut-worms were complained of as usual from all parts of the State. Those who made use of the poisoned bran remedy recommended by the Station, found little trouble in dealing with them, and the experience of the season warrants the statement that practical exemption from injury by these insects can be secured by the methods indicated in Bulletin No. 109.

Wire-worms have also had their points of abundance, and in some cases they were seriously troublesome to corn early in the season. Thus far we have no satisfactory method of dealing with these insects when once they have appeared in the field. Our measures are all in the way of prevention, and where a place has been exempt from injury by reason of a proper farm practice for a series of years, it sometimes happens that a false step results in an infested field which, when put into corn or potatoes, loses its entire stand.

Caterpillars of the cabbage butterfly were more abundant this

season than ever before in my experience. In some parts of the State there was scarcely a field of cabbage that was not seriously injured, and in many instances considerable areas were so damaged that the product was scarcely marketable. The use of Paris green as directed in the bulletins and reports of this Station is a perfectly safe and efficient remedy for this insect; but to be most satisfactory it should be applied early in the season, when the injuries first become apparent, and before the caterpillars have had an opportunity of boring into the head. This is one of the cases where promptness is essential, and it is this very point on which farmers are too often negligent.

There has been the usual complaint of injury from the potato beetle, and a reference to the extracts from the Crop Bulletin will indicate the localities where they appeared in unusual abundance.

Early in the season the currant span-worm made its appearance near Hilton, N. J., and did considerable injury. This is the first season that the insect has appeared in troublesome numbers within my experience, and the farmers did not recognize and were not prepared to properly deal with it. They treated it with hellebore, which proves satisfactory as against the ordinary currant worm; but was absolutely ineffective in this case. There is a very strong prejudice against applying the arsenites on currants when they have reached half size or more, and as a matter of fact it would be well to avoid using them when they begin to show signs of ripening; but if the application is made two weeks before any picking is done, at the rate of one pound in 200 gallons of water, it will be perfectly safe and will also be effective against the currant span-worm. In this, as in all other cases, the application should be made just as soon as the injury is noticed, and should not be delayed until considerable harm has been done, or until the size of the currants makes it undesirable to use the poison.

The experience with "Dendrolene" during the present season has not been quite as satisfactory as was hoped. Early last winter trees treated with this material showed not the slightest sign of injury of any kind, and so it was stated in the report for 1895. Early in the summer of 1896, however, it developed that on young, rapidly-growing peach trees, some injury had been caused where the material had been applied early in the previous year, and had remained on in a heavy coat for twelve entire months. The injury showed itself as a stoppage of growth at the point where the "Dendrolene" was

applied, and beneath it, the outer bark seemed to be dying off, while the inner bark was yet in good condition, though with an appearance as if serious injury might be expected unless the "Dendrolene" was promptly removed. Chemical tests showed that the material is as nearly as possible neutral. There is no distinct acid nor alkaline reaction, and there is nothing poisonous in it. It seems that the injury is done by the gradual penetration of the greasy mess into the plant cells. On trees with a thicker bark or of greater age, not the slightest injury was perceptible, and nowhere was any harm done on pear or apple trees where the application had been made. It seems, therefore, that a continuous coat of this material on thin-barked trees is inadvisable, and also that injury only shows itself at the end of a considerable period from the time of application. A coating that was retained only long enough to keep out borers during the danger season would still be safe, but the removal of the material would be a matter of some difficulty. I believe yet that the "Dendrolene" has a field in which it will eventually prove useful, but in its present shape it would not be safe to recommend it too generally. By mixing with something that would absorb most of the penetrating, greasy material, good results may yet be obtained, and experiments in that direction are in progress. This is one of the lines of work that was interrupted by the trip to California, and results cannot be reached in consequence for at least a year to come.

Complaints were received from several localities of injuries done to oak trees by some insect that caused the death of the small branches, and everywhere throughout the State, wherever oak trees were grown, in woods, parks or on lawns, dead twigs were numerous. The injury was most marked in those regions where the cicada appeared in 1894, and on examination it appeared that in twigs in which cicada eggs had been deposited the oak-pruner, *Elaphidion villosum*, had afterwards oviposited, and almost all that would have recovered from the cicada punctures were now being killed by the girdling larva. In some cases apple trees were attacked under the same conditions, and there were some reports of injury to maple from an insect either the same or closely allied. Whenever this trouble occurs on cultivated lands or in parks or gardens, a period can be put to the injury by gathering the dead twigs as they fall and burning them. The insect larva is in the end that drops to the ground and will be destroyed with the fallen branches. Such pruning as the trees receive under ordinary

circumstances from this insect is not serious, but there is no necessity for encouraging the increase of the species by neglect.

The bag-worm has again been abundant in many localities, and arbor vitæ hedges have suffered as never before. There has been comparatively little complaint of injury in orchards, but many a hedge in garden or park or inclosing a fine residence has this year suffered severely or been entirely killed. An arbor vitæ hedge entirely defoliated by this insect rarely recovers; hence any treatment must be promptly made as soon as the first signs of injury are noticed. The insects feed openly upon the leaves and are easily reached by any of the ordinary stomach poisons—arsenate of lead being preferable because of its safety on foliage.

There has been less complaint of the pear midge than usual, and I have no record of any considerable extension of the insect to the west or to the south. For some reason, the season did not seem favorable for the species, and no great spread was made. In the Hudson River Valley the circumstances were more favorable to the insect, and I am informed by Mr. F. A. Sirrine, one of the Entomologists of the New York Agricultural Experiment Station, that the kainit remedy recommended by me had been tried at Newburg, N. Y., with excellent success. He writes: "Mr. J. R. Cornell, of Newburg, N. Y., obtained flattering results from the use of kainit. My traps showed only about one midge where kainit was used to about 500 where no kainit was used." This is strong confirmatory evidence to the results already obtained by me, and indicates that this pest may be kept in subjection. Mr. Sirrine adds that an orchard "which he had cultivated carefully was just as free from the midge as the one where kainit was used and not cultivated, while a neglected orchard had very little fruit not infested." In other words, frequent stirring of the soil will result in the death of a very large proportion of the midges. The larvæ will be exposed to their natural enemies or will be deeply buried, so that they cannot emerge even if they transform. In the one case the remedy is mechanical, in the other case it is chemical, and both measures are good. Plowing an orchard infested by the midge after the middle of June, or in fact at any time during the summer, so as to turn under the top soil at least four inches, will probably result in burying beyond resurrection a great proportion of the midges. It would not be bad practice to combine the two methods—to apply the kainit about the middle of June, as recom-

mended by me, and some time in July or August, whenever circumstances are most suitable, to plow under whatever may be on the surface. The potash would not be lost and cultivating the orchard would certainly take nothing from it. An orchard that is seeded to crimson clover should have the clover turned under before the midges leave the pears, and the potash then applied in the kainit would complete the fertilization of the orchard.

In several places in the southern part of the State, pine forests were considerably injured by the attacks of the pine saw fly, *Lophyrus abbotii* Leach. From Brown's Mills complaint came June 11th: "I noticed them a few days ago. They work very fast, and have already eaten up fifty acres. Our oldest residents cannot remember seeing such a worm." Of course, the insect is present more or less abundantly each year, but rarely in such numbers as to defoliate trees or large tracts. Our methods of dealing with insects injurious in forests have not yet advanced to such a point that recommendations likely to be adopted could be made.

In September, the enormous increase of the vine leaf hopper, *Erythroneura vitis*, was noticeable in vineyards everywhere throughout the State, but particularly in the southern counties. The leaves were universally turning brown and dry, and any disturbance of the foliage caused clouds of these little insects to arise. On some leaves there was not a space a quarter of an inch in diameter which did not contain punctures of these insects, and wherever a puncture had been made a little brown spot resulted, which increased in size until the entire foliage became dead and dry. This was early enough in the season to make it desirable for the foliage to retain its vitality in order to mature the wood properly, and therefore some injury resulted. Little attempt was made to treat them, and probably not much good would have been accomplished had the treatment been made in September; but a month or two earlier, before they were so abundant and troublesome, it would have been easy to reduce them to harmless numbers by spraying with the kerosene emulsion, or even by using the palm leaf fan remedy recommended in previous reports. Where vines are strung on wires, walking between them with palm leaf fans covered on both sides with gas tar, disturbing the foliage and swinging the fans, results in capturing on the sticky surfaces much the largest proportion of the insects. By repeating this two or three times

a week for two weeks, practical exemption for the balance of the season can be secured.

Shade-tree insects have aroused increased interest throughout the State. At more points than ever before were active measures taken to control injury by the elm-leaf beetle, and in a number of instances city improvement societies or township committees took hold of the matter with beneficial results. The distribution of this insect was uneven in 1896, and while much injury was done in some parts of the State, in others there was much less than ever before. This was due to a large extent to climatic conditions. In New Brunswick, I found on my return from California that, except where spraying was done, larvæ were present in very large numbers; but just about the time of pupation the weather became such as to check further development. It was cold and wet, and the nights in some instances were quite chilly. The result was that much the greatest proportion of insects died in the pupal state, and only a very small percentage of crippled specimens attained the adult or beetle stage. The mortality among them was simply enormous, and it would seem as if the prospects for next year were that only a small proportion of specimens would survive, and that little or no injury will be done.

In some parts of the State the cottony maple scale seems to have been quite numerous, and some alarm was occasioned by its occurrence; but it disappeared, as was to be expected, toward the end of the season, and the set of young, where I had an opportunity to make an examination, did not seem to indicate any very large increase for next year.

The *Pseudococcus aceris* was present this year in much the same localities where it was noticed in 1895. As a whole, however, there seemed to have been less of it. Whether this was due to the character of the season, or to any lessening of vitality in the insect, it is impossible to say at present. At all events, trees in New Brunswick did not become nearly so densely covered as they did in 1895.

Another scale that seems to have found a series of favorable seasons is the tulip soft scale, *Lecanium tulipifera*. This was sent in from several sections, and was reported as seriously injuring the trees.

An unexpected occurrence was the sudden increase of a little click-beetle, *Monocrepidius vespertinus*, which was complained of from Atlantic county on sweet potatoes. It was said that they split the stem of the plant about an inch below the surface, which turned the

plant black and finally killed it. Last season the same species appeared in the same county, the pods of beans being eaten into in such a way as to make them unfit for market. This insect has not been injurious in the past, and its sudden increase is probably due to some local cause which favored development during the past season. It is to be expected that the injury will remain local, and that it will be less next season than it was during the present. It seems to be one of those cases where an otherwise harmless form suddenly escapes from its natural checks, and becomes locally and temporarily troublesome.

Another insect which was unusually abundant during the summer, although not infesting cultivated plants, was the locust-leaf beetle, *Odontota dorsalis*. In many cases the trees were almost entirely stripped of their leaves, the beetle feeding on the tissue itself, while the larva burrowed between the upper and lower surface in such a way as to turn them dead and brown. Accompanying this increase of the species feeding upon the foliage, the borers also became more abundant, and more complaint was heard than ever before in my experience. Practical measures to prevent injury from these borers cannot be recommended until an entire neighborhood agrees to enforce them. It is simply impossible to protect an individual tree, or a set of trees, in any locality where any large number of locust trees occur. It would be possible, however, to protect the trees of a large district, provided the inhabitants of the district would agree to adopt similar measures.

A quite unexpected occurrence of the "harlequin cabbage bug" was reported by Mr. I. W. Nicholson, in Camden, in September. This insect is an extremely difficult one to contend with in the Southern States, and of late years has been traveling north, principally through the Mississippi Valley region. I have found it in New Jersey in occasional specimens for some years, but this is the first instance in which it has been reported in troublesome numbers. As it may be that the insect is gaining a foothold in our State it is well that our growers should know about it, and a brief account of the insect and of the best methods of dealing with it, will be found in another portion of this report.

A great deal of material has been added to the economic collections of the department. No opportunity has been missed for obtaining material illustrating all the stages of the injurious insects of the State,

or those likely to become so, and wherever possible examples of the injury done have been collected. In the arrangement of the material the object has been to show injurious insects in all their stages, and the injury done by them. Furthermore, it is intended to arrange the collection in such a way that the insects injurious to special crops will all be gathered together; so all insects injurious to corn will be grouped, and those injurious to apples, and so on through the list. There are now on exhibition 44 arranged cases; at least 10 others are in cabinets, and the material on hand is sufficient to fill at least 50 additional boxes when opportunity for arranging them can be found.

The Entomologist has continued to derive assistance from collectors and students in Brooklyn, New York, Newark and Philadelphia; and by attending as many entomological meetings as feasible in these cities it has been possible to obtain a great deal of information and material that could not have been gathered in any other way. The gentlemen in those cities in fact constitute a sort of voluntary corps of assistants, and are always ready to do what is possible to secure specimens desirable for the collection of the Experiment Station. The Entomologist has also attended the meeting of the Association of Economic Entomologists held at Buffalo, N. Y., August 19th to 21st, inclusive. The discussions at these meetings were of the utmost value, and as the membership consists almost exclusively of working entomologists, and principally of those employed in Experiment Stations, the opportunity for exchanging experiences and learning methods of work is extremely valuable, and was taken advantage of to the full.

The correspondence of the office has been larger than ever, and covers for the year 1,415 pages of letter book. In the early part of the year institutes were attended in a large number of counties, and lectures, generally illustrated by lantern slides, were delivered before farmers in all parts of the State. This has aided greatly in familiarizing the Entomologist with the wants of different sections, and has at the same time brought home to the farmers themselves the work of the Station, and shown them the nature of the efforts being made in their behalf. The result has been increased confidence in the Station and increased number of applications for advice.

Entomology in the Crop Bulletin.

Potato beetles were first complained of on May 4th, from South Dennis, Cape May county, where they were said to be "plentiful." May 11th, at Ranocas, Burlington county, farmers were "getting ready to wage the usual war on potato bugs." In Ocean county, "the warm weather of the 4th brought great numbers of potato bugs." May 18th, the bugs were "in unusual numbers" at Ranocas, Burlington county; they were "more numerous than ever before and very destructive" at Woodbury and Swedesboro, in Gloucester county; were "just making their appearance" at Kingwood, in Hunterdon county; were "very thick" at Piscatawaytown, in Middlesex county; "more numerous than in previous seasons" at Staffordville, Ocean county; and "very numerous" at Woodstown, in Salem county. May 25th, white potatoes were "greatly damaged" at Vineland and Deerfield, in Cumberland county, "some patches of potatoes being plowed up" on their account; they appeared "in great numbers" at Sergeantsville, and were "very plentiful" at Rowland's Mills, in Hunterdon county. In Mercer county, they were "busy" at Trenton, and "unusually bad" at Trenton Junction. In Middlesex county they "were never so numerous," at Metuchen, and at Toms River, in Ocean county, they were "worse than ever before." June 1st, they were "numerous" at Frenchtown, in Hunterdon county; were "plentiful" at Trenton Junction, in Mercer county; "numerous" at Peapack, Somerset county, and "plentiful" at Rocksbury, in Warren county. June 6th, they were "plentiful" at Woodbine, Cape May county; were "injuring tomatoes" at Deerfield, Cumberland county; were "in great abundance" at Livingston, Essex county, and were "not as bad as usual" at Boonton, Morris county. July 6th, they were "very bad" at Rocksbury, Warren county. July 13th, they were reported "not as bad as last year" from Peapack, Somerset county. July 27th, they were reported "numerous" at South Dennis, Cape May county.

Cut-worms were first reported as "doing much damage" May 18th, from Egg Harbor City, Atlantic county. They were "cutting plants and vines badly" at Millville, Cumberland county, and were "doing some damage" at Mount Airy, Hunterdon county. May 25th, they were "doing considerable damage" at Flemington, and were "cutting corn" at Kingwood and Mount Airy, in Hunterdon county. They

were "abundant" at Hightstown, and "busy" at Trenton, in Mercer county. They were "destructive in places" at Cassville, in Ocean county. June 1st, "they were cutting corn and damaging plants badly" at Mount Holly, in Burlington county; were "less troublesome" at Mount Airy in Hunterdon county; but at Readington "some cornfields required replanting on their account." June 8th, injury was reported from Rowland's Mills, and "some complaint was made" from Readington, Hunterdon county. "Some replanting was caused" at Imlaystown, Monmouth county. Corn was "backward on their account" at Fredon, and they were "causing havoc in some fields" at Deckertown, Sussex county. At South Bound Brook, Somerset county, corn was "doing well where not injured by cut-worms." They "did not do much injury" at Titusville, in Mercer county; but were doing "damage to tomatoes and cabbage" at Charlottesburg, Passaic county. July 6th, "some replanting was necessitated by cut-worms" at Beverly, in Burlington county. July 27th, they were reported as "injuring cabbage" in Dover township, Ocean county, but the poisoned bran remedy was said to be satisfactory for their destruction.

The *strawberry weevil* was complained of May 18th, from Deerfield, Cumberland county, and this was the only complaint made of this insect during the season.

Onion maggots were also reported from Cumberland county May 18th, but from nowhere else, nor later in the season.

The *pear midge* caused "an almost total failure of the crop" near Hilton, in Essex county, May 18th. It was "doing some damage" at Metuchen, May 25th. June 1st it "nearly destroyed the pear crop" at Piscatawaytown, Middlesex county.

Currant worms were complained of from Kingwood, Hunterdon county, May 18th, and they were "numerous" at Frenchtown June 1st.

Tent caterpillars were first noticed at Kingwood, Hunterdon county, May 18th. They were "troublesome" at Shiloh, Cumberland county, June 15th. They "appeared" at Sergeantsville, Hunterdon county, June 22d; were "bad on fruit trees" at Kingwood and Readington, Hunterdon county, June 29th; were "in great numbers" at Seargeantsville, Hunterdon county, July 6th, and "were again troublesome" at Shiloh, Cumberland county, August 10th. Finally they "abounded" at Ocean View, Cape May county, August 31st.

On May 18th, *flea beetles* were complained of as injuring potatoes at Oceanic, Monmouth county, and Piscatawaytown, Middlesex county.

Wire-worms were said to be "busy" at Trenton, Mercer county, May 25th. On May 29th, "recovery from wire-worm attack" is recorded from Mount Holly, in Burlington county.

Army worms were first complained of May 25th, from Manasquan, Monmouth county, where they were said to be "playing havoc with wheat, corn and grass." June 1st, they were reported from the same place as "still injurious," and from Freehold the report was that it had appeared in a few sections." June 8th, Freehold again reported "some damage," and June 15th, Farmingdale reports "wheat eaten by a worm said to be the army worm." Manasquan reports the disappearance of the insect. July 27th, it appeared at Papakating, in Sussex county, where "several fields of oats were said to have been destroyed."

June 1st, it was reported from Rocksburg, Warren county, that "insects were destroying wheat in many places," but unfortunately the kinds of insects were not specified.

June 8th, it was reported from Hammonton, Atlantic county, that "peaches and apples have dropped badly on account of the curculio."

Ants were said to be "damaging corn to an unusual extent" at Rocksburg, Warren county, June 8th.

The *grain louse* was reported as doing damage, June 8th, in Dover township, Ocean county.

June 15th, "a worm" was injuring tomatoes at Bridgeton, Cumberland county.

The *web-worm* had "destroyed some fields of corn" at Cassville, Ocean county, June 15th.

Weevils had "badly damaged corn" at Huntsburg, Sussex county, June 22d.

June 20th, *plant lice* were complained of on lima beans from Ocean View and South Dennis, Cape May county, and from Shiloh, Cumberland county. July 13th, they were again reported from Ocean View, Cape May county. July 20th, there was "some complaint of their injury to lima beans," from Friesburg, Salem county.

Plant lice on melon vines were reported July 6th from Moorestown, Burlington county, from Beesley's Point, Cape May county, and they were "destroying melons and cantaloupes" at Swedesboro, Gloucester county. July 13th, they were "reported" from Mount Holly, Bur-

lington county, were "bad" at South Dennis, and "present" at Ocean View, Cape May county. At Swedesboro they were "destroying many fields of watermelons and cantaloupes," and in Dover township, Ocean county, kerosene was being used for their destruction. July 20th, the insect was "still spreading" at Beesley's Point, was "troubling muskmelons" at Millville, "injuring melons" at Bridgeton, and had "ruined many melon patches" at Deerfield, all in Cumberland county. It was "troublesome" at Paterson, Passaic county, and was "doing great damage and entirely destroying some patches" at Pennsgrove, in Salem county. July 27th, "vine truck of all kinds was suffering, and some fields are entirely destroyed" at Rancocas; they were "making havoc with melon and pickle vines" at Mount Holly, and were "still destroying melon and kindred vine crops" at Moorestown, all in Burlington county. The crop was "short on account of the lice" at Ocean View, Cape May county. They were "destroying citron and watermelon vines" at Haddonfield, Camden county, were "still affecting melons" at Bridgeton, "damaging" them at Deerfield, "troubling" them at Millville, but "had not appeared" at that date at Vineland, all in Cumberland county. Woodbury and Swedesboro, in Gloucester county, report nearly all fields destroyed by lice. Farmingdale, Monmouth county, reports the crop "damaged," and Pennsgrove, Salem county, reports them as "doing great damage to melons and cantaloupes." August 3d, Linwood, Atlantic county, reports that "watermelons and cantaloupes will in some cases be failures on account of the lice." The vine crops were "destroyed" at Rancocas, the "plantings were of little value" at Moorestown, and the lice were "seriously troubling the crop" at Mount Holly, all in Burlington county. At Haddonfield, Camden county, lice had "completely destroyed citron vines, and farmers have planted sugar corn in their places." Injury was "very bad" at Ocean View, Cape May county. It "still continued" at Bridgeton, Cumberland county, was "badly affecting melons" at Hightstown, Mercer county, "badly injuring the crop" at Woodstown, Salem county, and "destroying nearly the entire crop" at Finesville, Warren county. August 10th, Rancocas reports "heavy rains which destroyed the lice and started melons to new growth." Mount Holly reports "continued injury." Rowland's Mills, in Hunterdon county, reports "a few lice," and Papakating, in Sussex county, reports "none present." August 17th, "continued trouble" was reported from Beverly, in Burlington county; injury "still continued" at Ocean View, Cape May county,

but there was "not much complaint" at East Brunswick, Middlesex county. August 24th, "melon vines relieved of lice by lady birds were growing" at Moorestown, Burlington county.

June 29th, Fairmount, Hunterdon county, reports that "peaches are dropping because stung by a small fly."

The *Hessian fly*, July 6th, did not "bother the wheat to any extent" at Deckertown, Sussex county; but "with the winter, had injured much wheat at Broadway," in Warren county. This crop was "poor in quantity and quality, owing to the ravages of the Hessian fly," at Rocksbury, but at Belvidere, both in Warren county, "only a slight damage" was reported. September 7th, "very little seeding had been done" at Rocksbury, in Warren county, "on account of drought and fear of Hessian fly."

"Numerous worms on grapevines" were reported from Beverly, Burlington county, July 13th.

Insects in general were causing great destruction to tomatoes, squashes, cabbages and potatoes in Dover township, while "squash bugs by the thousand" made their appearance at Toms River, Ocean county, July 20th.

Potato stalk borers were complained of from Titusville, Mercer county, July 27th, and were said to be "badly infesting the crop" at the same place August 3d.

Cabbage worms were "bad" in Dover township, Ocean county, July 27th. September 7th, they were "injuring cabbage" at Raucocas Burlington county, at Ocean View, Cape May county, and at Piscatawaytown, Middlesex county.

The *Texas or horn fly* was troubling cattle at Papakating, Sussex county, August 3d. It was making the animals "almost desperate and shrinking the milk-supply" at Mount Holly, Burlington county, August 10th, and on that day Mr. E. T. Gill, of Haddonfield, reports that "for the Texas horn fly we use sturgeon oil, with very little carbolic acid mixed, and find it very satisfactory, putting it on with a whitewash brush every other day."

A "new worm on apples" was complained of August 24th from Hammonton, Atlantic county.

Cranberries were reported as much injured by insects from Laurel Springs, Camden county, September 7th.

Corn was "badly affected with worms" at Cassville, Ocean county, September 7th.

The Army Worm.

(*Leucania unipuncta* Haw.)

Few things are more interesting from a scientific standpoint or more startling from an economic point of view, than the occasional sudden and apparently unexplainable increase of certain species of insects. An example of this, in the form of an "army worm" invasion, was forced upon the farmers of New Jersey and many of the other Eastern and Central States during the season of 1896.

The "army worm" is an old offender, well known in the literature of economic entomology, and has in times past done enormous injury east of the Rocky Mountains. Its appearances have always been irregular, and it has never been possible to predict with any degree of certainty just when a serious invasion would take place. We have only been able to say, from past experience, that after one year of severe injury by the insect, the probabilities are all against its putting in an appearance the year following in destructive numbers; that is, two invasions do not, under ordinary circumstances, follow each other. So far as I have any records in the matter, the last "army worm" year in New Jersey was in 1880, and an account of it is found in the annual report of the Entomologist to the United States Department of Agriculture "for the fiscal year ending June 30th, 1882."

The adult insect is well known as one of the common species of Noctuids, or "owlet moths," and specimens are found each year by the Entomologist in considerable numbers and at nearly all times during the season. There is, however, a tendency to an increase in the number of specimens towards fall, and when engaged in "sugaring," the collector is sometimes almost driven to despair by finding nothing but these common moths, instead of the rarer and better species which he was in hopes of attracting to his lures. With a fair number of specimens on hand from year to year, the nucleus for a destructive increase is always present. Under ordinary circumstances, parasites, predatory forms, and, more than all, climatic conditions, keep down the species to about the same number year after year; and this number is so small that no harm is done to cultivated crops. A change in climatic conditions in the direction of an abnormally dry year, followed also by a dry spring, may result in an unusual increase of the insects, particularly if the winter was rather continuous, that is

to say, was not one of frequent change from freeze to thaw. From my own observations I feel certain that the insect may pass the winter in any except the egg stage. I have found the moth during the entire winter in sheltered situations, and have found, very late in fall, caterpillars of all sizes and newly-formed pupæ. It has been satisfactorily proved that the partly-grown larvæ live through the winter, and I feel certain, though I have no direct proof on this subject, that the insect may winter in the pupal stage as well. The result is that in an abnormally dry year we may have, passing through the winter, an unusually large number of the insects in all their stages. In spring the hibernating individuals become active; a very brief period of warm weather serves to bring out moths from the hibernating pupæ, and in less than a month after the opening of spring, moths from the hibernating caterpillars will also be found.

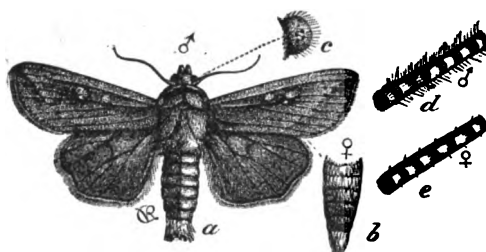


Fig. 1

Leucania unipuncta, parent of army worm: a male moth; b, abdomen of female; c, eye, covered with hair; d, antenna of male; e, of female. (After Riley.)

These moths are of a dark, reddish clay color, powdered with black atoms, and measure, with wings expanded, about one and three-quarters inches. The fore-wings are narrow, triangular, with the apex or tip pointed, and marked with a whitish streak through the middle, to a rather larger white blotch near

the center of the wing. There is an oblique dusky streak toward the tip of the wing, and there are two, lighter reddish spots, nearer to the middle of the front margin. The lower wings are rather paler in color and much more thinly scaled, without any distinct markings. The insects fly only at night, and are not found during the day except by accident, or when disturbed from their shelter. At dusk they begin to move and to seek for food, which consists of any sweet liquid substance that they can find. They frequent flowers at this time, and may be of some use as pollenizers on fruit trees; but their usefulness in this direction can scarcely be very great, and can hardly balance the injury frequently done by the larvæ. A curious fact was the occurrence of the moths in large numbers among

the plant lice on the melon vines, reported from southern New Jersey, where they were undoubtedly attracted by the sweet secretion of the Aphids.

The eggs are laid in grasses or grain, and a favorite place is along the inner base of the terminal blades, where they are double, or between the stalk and its surrounding sheath. They may, early in the season, even oviposit in the cut straw of old stacks or in hayricks, or even on bits of cornstalk in the field. In fact, the moth will use almost any place that offers an opportunity for depositing her eggs—favoring, under ordinary circumstances, grass or grain, as already described. It is usually the rankest bit of wheat or grass that is first infested by army worms, because the moth finds in such spots more shelter for the five to eight hundred eggs which constitute her supply.

The eggs are laid close together, in series of twenty or more, and are covered with a whitish, adhesive fluid, which fastens them to each other and holds them in position on the grass blade. The eggs hatch in about a week from

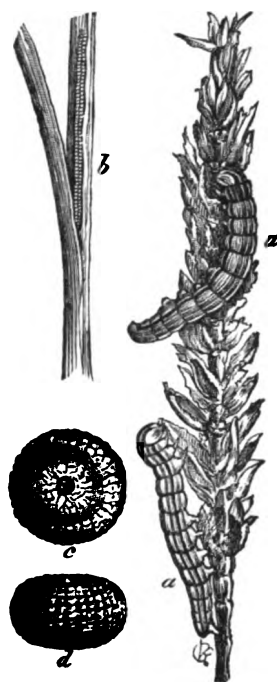


Fig. 2.

The wheat-head army worm feeding on wheat kernels, as does the true army worm, which it closely resembles; *b* shows how eggs are laid; the eggs enlarged at *c* and *d*. (After Riley.)



Fig. 3.

The army worm, nearly full grown. (After Riley.)

the time that they are first laid, and bring forth a larva or caterpillar which is dull reddish or brown in general color and marked with yellow and black longitudinal lines. Growth continues until the caterpillars become nearly two inches in length, and then they make their way to the surface of the ground and a little distance beneath it change to mahogany-brown pupæ, which vary from one-half to three-quarters of an inch in length. In from one to two weeks afterward the moths make their appearance, and shortly thereafter another

life cycle begins. Under ordinary circumstances, six weeks from the egg to the resulting adult is about normal; but during mid-summer, especially in years when the insects become very abundant, the period may be shortened, and one month may be sufficient to pass through the entire cycle of changes. The first brood of caterpillars rarely does much damage, even if it is quite abundant; but the second, if the weather has been favorable during the early part of the season, may become enormously abundant; so that when the insects are half grown or thereabouts they eat themselves out of food where they originally started and find it necessary to move elsewhere in search of provender. This habit of wandering from place to place in search of food has given the insects the name "army worm." The term "army" is no misnomer if numbers suffice to constitute an army. Millions of specimens are sometimes seen on the move, all in the same direction; but this is not an example of concerted action in following any leader or set of leaders. It is merely the mechanical movement in a direction in which a start was made by the first that sought other food. When any large number of specimens are on the move, one general direction will be almost certainly taken, because in no other way can the insects get along without climbing over and hindering each other's progress.

The caterpillars feed preferably at night and, unless they are very abundant, usually hide during the day at the roots of the grass or grain on which they feed. As to the number of broods, this depends much upon locality and season. In New Jersey, as nearly as I can make out, three annual broods are normal; but in the southern counties a fourth is by no means unusual, and probably there is at least a partial fourth brood in most years. The summer of 1895 was emphatically a dry one in most parts of the State. The winter also was, comparatively speaking, a dry one, and it was not one that offered any very marked contrasts or sudden changes which would result in killing off any large proportion of hibernating insects. Mere cold is never a good destroyer of insects, but a sudden change from a thaw to a hard freeze always proves fatal to a very great number. The spring of 1896 was also favorable for the multiplication of the insects, and so even the first brood became troublesome in some localities.

The insects made their first appearance this year in Monmouth county, so far as reports have come to hand. They were already

injurious on May 29th, at Manasquan, where they were "playing havoc" with wheat, corn and grass. May 27th, they were reported from Ardena as destroying a field of wheat. They were noticed there May 16th, and were then quite small in size. At the time of writing (May 27th) they were nearly full grown, and were leaving the wheat which had been first attacked. They remained at Manasquan until about the middle of June, when they disappeared. June 1st, they were reported from a few places in the vicinity of Freehold, and June 15th, a report of wheat eaten by them came from Farmingdale. June 7th, the news came from Glen Ridge, Essex county, that specimens were found in a field of oats. July 9th, the insect was reported from a few fields of rye, grass and corn, in the vicinity of Montague, Sussex county. July 15th, it was announced that the army worm had put in an appearance at Bloomsbury, Hunterdon county. July 13th, it appeared in a single field at Cologne, Atlantic county, and ruined between four and five acres of oats. By the 17th of that month they had almost disappeared, and nothing further was heard of them afterward. July 27th, several fields of oats were said to have been destroyed near Papakating, Sussex county. Finally, on September 6th, they appeared in a field of Hungarian grass, at Englewood, Bergen county. Some time during the middle of July an oat field near New Brunswick became infested by the insects, but comparatively little damage was done.

The above record indicates the curious distribution of the insect and illustrates the fact that comparatively little injury was caused. In some places, as for instance Cologne, only a single field was infested, and their occurrence in Middlesex was confined to a single patch of oats. The Englewood appearance was limited to a field of Hungarian grass, and in most other cases only one or a few fields were attacked by the insects. It is noticeable, too, that in no locality was more than one brood troublesome. Early in the season they appeared in Monmouth county; but after their disappearance in June, nothing more was seen or heard of them. Altogether, the actual damage caused by the insects was not very great. A few farmers suffered the loss, in part at least, of the oat crop, and here and there grain was somewhat injured; but nowhere was there any sweeping destruction. In some cases corn was attacked by the half or three-quarter-grown larvæ; but eating continued so short a time that no real damage was done, so far as I have been able to ascertain. As already

indicated, it is not at all probable that the insect will make its appearance next year; but as it is within the range of possibilities, it may be best to have some information as to how to deal with it in case it does come.

Natural Enemies.

This insect, under ordinary conditions is kept under control by—first, climatic conditions which favor the development of diseases; second, by insect enemies. The climatic conditions that favor the development of diseases are more or less wet and oppressive weather during the summer, and cold, wet weather in fall and spring. The insect enemies of the caterpillar are quite numerous, and include both parasites and predatory forms. As the insects remain preferably upon the surface during the day, except when they are very abundant or in corn, ground beetles have an excellent opportunity of feeding upon them. Among these, the “fiery

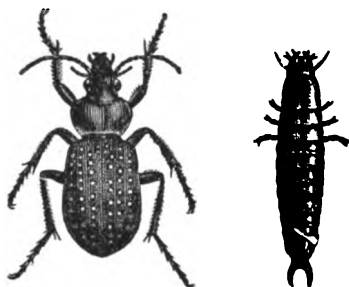


Fig. 4.

The fiery ground beetle (*Calosoma calidum*) and its larva. (After Riley.)

ground beetle,” *Calosoma calidum*, and its larvæ are the most effective. I have found them everywhere present in a field attacked by the army worm, and they were so abundant that even the farmers observed them. For instance, Mr. George W. Patterson, Jr., of Ardena, Monmouth county, writes: “They also had an enemy, a black bug—very voracious—which girdled their throat one after another in the hills.” This evidently referred to the larva of this beetle, which is black, elongate-oval in shape, and about three-quarters of an inch in length when full grown. It has prominent jaws or mandibles, by means of which it can easily puncture and tear the comparatively soft skin of the caterpillar. It sometimes seems to



Fig. 5.

Army worm tachina fly (*Nemoreia leucania*), showing the eggs on the body of the caterpillar, the larva, pupa and adult. (From the Div. Ent., U. S. Dep't Agriculture.)

kill from the mere love of killing, and bites into many more caterpillars than it can possibly consume.

The most effective enemy, however, is a parasitic fly, *Nemorea leucania*. This is a somewhat bluish fly of quite a good size, resembling, perhaps, most nearly, a small "blue-bottle," but set with prominent black spines. It lays its eggs, which are white and oval in shape, on the back of the caterpillar as near to the head as possible, selecting this locality because it makes it impossible for the insect to get at the eggs to tear them off. Scarcely a caterpillar could be found in some of the infested fields that did not have glued to it from one to six or eight of these white eggs. From these hatched in a few days a small maggot, which bored through the outer skin of the larva and fed upon the fatty matter within its body. Of course all such larvæ were doomed, and while they might become nearly or quite full grown, and might even pupate, yet they never could turn into moths and thus get the opportunity to reproduce. These flies are always active, and usually increase nearly as fast as the caterpillar does. When, however, under favorable conditions the caterpillar outruns them, it never gets more than a brood or two the advantage before the flies catch up and succeed in reducing the insects to harmless numbers. The extreme value and effectiveness of this fly could not be better appreciated than when gathering caterpillars with the object of bringing them to maturity. Scarcely one in one hundred was free from eggs of this parasite, and I am inclined to attribute the check that the caterpillars received after one injurious brood in this State, almost exclusively to the work of this insect. So long as this continues with us, it does not seem possible that the army worm can flourish in injurious numbers for two years in succession, or that it can, within a single year, have more than one troublesome brood. .

Remedial Measures.

The fact that this insect attacks grain, grass and corn makes it very difficult, if not impossible, to apply insecticides to destroy it. The application of arsenites in a grainfield is almost a hopeless task, and the difficulty of making the material stick on the slender blades is so great that it is hardly worth while recommending the use of sprays. It has been found, however, by practical experience, according to the

statements of Dr. J. A. Lintner, that the army worms are, like the out-worms, extremely fond of bran, and that they may be attracted to it quite as readily. As they feed chiefly during the night, on grain or grass, and spend the day near the base of the plants, it is necessary only to scatter little masses of poisoned bran throughout infested fields in order to rid them in two or three days of the army worm. By applying the bran in the late afternoon it will attract a very large proportion of the caterpillars the first night, and will remain in good condition to attract them for at least one if not two nights more. It has been said that the caterpillars are able to perceive its presence for quite a distance, and that they would leave even corn upon which they were feeding to find a little pile of bran as much as six feet from the base of the plant. Wherever this bran remedy is feasible, it is a good thing to use. In all cases it is important that active measures be taken against the insects at once. If they are noticed while yet quite young, the chances are that they will be found confined to a comparatively small area, and an immediate liberal application of the poisoned bran may serve to prevent further injury.

Should this suggested remedy be unavailable for any reason, or should the insects when noticed show a tendency to move from an infested field, the best measure is to isolate by plowing at least one deep furrow entirely around it. The furrow should be made just as deep as possible, and the side from the field should be made as steep as the earth will lie. Bad places in the furrow should be mended up with a spade, and post-holes should be driven in the furrow at intervals of not more than ten feet. The caterpillars, in attempting to leave the infested field, will find no difficulty in getting into the furrow, but will find themselves unable to crawl up on the other side, and will move along the bottom, seeking for a better place, only to tumble into the post-holes driven to receive them. From these they are unable to crawl, and they can be killed at intervals, either by pouring kerosene into the holes or by simply crushing with a pounder of proper size and shape. Instead of a single furrow, two or three may be made to obstruct the passage and tire out the insects, but in one of them there should be a series of post-holes to trap them. If the furrow is of a proper kind, it will need looking after only once or twice in the course of twenty-four hours. This method means abandoning the infested portion of the crop, but it will serve to secure

everything outside of it. Here again it is important that the insects should be noticed and attacked when young, because if a start be made from a limited portion of a field, by isolating this infested part the rest may be saved. This method of furrowing or ditching is in general the most satisfactory one, and its results are good, so far as limiting injury is concerned, in proportion to the promptness with which the presence of the insects is noticed and the remedial measure is resorted to.

Occasionally, when the caterpillars are noticed in a very limited part of a field—usually the rankest and most thrifty portion—it will be possible to use kerosene for their destruction. If the caterpillars are already more than three-quarters of an inch in length, the kerosene should be used pure and should be thoroughly sprayed upon the infested plants when the insects are feeding in the early evening. This may kill the plants, but it will also kill the insects and will limit the injury at once. It is sometimes possible to cut down a small infested plot, leave it to dry during the day and then burn it over, destroying the worms with the cut grain. This measure, of course, must be used with care, in order to prevent the fire from running away and causing more harm than good.

In all cases it is important that measures should be taken early, and very desirable that the insects should be noticed as early in their career as possible, before they have spread over any large territory. They always start from some central point, and the sooner measures are taken after the start the more limited their injury will be. It is almost always safe to accept as a total loss any portion of a field that is badly infested and to adopt measures which will look chiefly to the protection of the balance of the crop. If we apply kerosene pure, it will probably kill most of the plants as well as the insects. If the application is made while the caterpillars are less than one-half an inch in length the kerosene may be emulsified and the emulsion may be diluted five times. This kills the insects at that stage of growth and will not be apt to harm the crop; but the application must be made very thoroughly, and in fact all measures will be found successful in proportion to the thoroughness with which the applications are made.

The Harlequin Cabbage Bug.

(*Murgantia histrionica* Hahn.)

This is an insect which, up to the present time, has not been injurious in the State of New Jersey. It has been, heretofore, known as a typical Southern insect, and has been one of the most difficult to deal with of all the pests there affecting cabbage.

In September, 1896, Mr. I. W. Nicholson, of Camden, notified me that some insect, theretofore unknown to him, was attacking his turnips and apparently doing considerable injury. Later, at my request, he sent specimens, which to my surprise proved to be this harlequin

bug in all its stages, from the egg to the adult. The insect is not entirely new to New Jersey, for I have taken specimens for several years past in the southern counties; but always singly and never as a pest in cabbage-fields. The species has been traveling northward from its southern home for a number of years, and Mr. F. M. Webster has very interestingly followed its track in the State of Ohio, noting a northward advance of something like 18 to 20 miles per annum.

I have had the species from

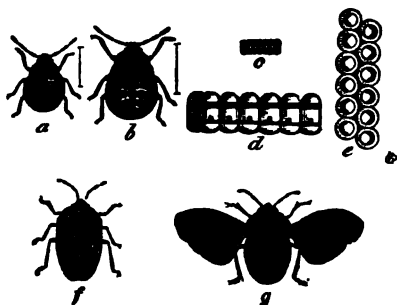


Fig. 6.

The harlequin cabbage bug (*Murgantia histrionica*) in all its stages: a, b, larva or nymph and pupa; c, egg mass, natural size; d, e, same, enlarged, seen from side and from above; f, g, adult at rest and with wings spread. (From the Division of Entomology, U. S. Dep't Agriculture.)

Pennsylvania on various occasions, and it has been claimed as an injurious insect there by several persons who have written me on the subject. There is now a strong possibility that south of the red-shale line in our State, the insect may get a foothold, and may become another serious pest difficult to be dealt with. It is well, under the circumstances, that the farmers should know the insect when they see it, and should have some idea of how to handle it. It may be said, in this connection, that Mr. Nicholson claims that he has never seen the insect before this year, and as Mr. Nicholson is a careful observer, the insect, if present at all, must have occurred in very small numbers to escape detection.

The harlequin cabbage bug is so called because of its mottled red and black color, which makes it easily recognizable in all its stages. Even the eggs, which are laid in groups, are banded pale yellow and black, so as to form quite prominent objects on the leaves. From these eggs hatch little black, yellow and red-dotted bugs, which at once begin feeding upon the juices of the cabbage plants, exhausting them and causing the leaves to lose vitality, eventually to dry, shrivel and die. As the bugs increase in size, rudiments of wings begin to appear, until, when full grown, they are about two-fifths of an inch in length and one-third of an inch in breadth. The figures herewith given illustrate all the stages, the colors being black, yellow and red. The insects live through the winter in the adult condition, finding shelter wherever they can in the fields, under rubbish, along fences overgrown with weeds, in outhouses and barns, in corn shocks, or in fact wherever there is an opportunity to hide and secure covering and protection for the winter. They make their appearance in spring as soon as the warm weather fairly sets in, and at that time feed on whatever cruciferous plants they are able to find. They are particularly fond of mustard, wild as well as cultivated, and up to midsummer seem to prefer radishes to cabbages. Eggs are laid on the under side of the leaves in double rows of usually about twelve, but sometimes more than twice as many. Their general appearance has already been described, and they hatch in from two to eight days, depending considerably upon the temperature. As soon as they are hatched the young begin their destructive work, and increase in size rapidly, reaching maturity in from twenty to thirty days after the eggs or laid. They grow very much more quickly in midsummer than they do earlier or later in the season, and have been reported as reaching full size in as short a time as two weeks. This enables them to produce several broods during the season, and of course each becomes successively more injurious. No observations have as yet been made upon the insect in New Jersey, therefore their exact life history with us is unknown, but we can count upon at least three broods, and probably a fourth as well. The insect, therefore, becomes most abundant on the late cabbage, or on other cruciferous crops which are raised in the fall of the year.

Remedial Measures.

As this is a sucking insect, feeding only upon the juices of the plants attacked, stomach poisons cannot be used for its destruction. The arsenites and similar materials are therefore excluded and kerosene or a soap mixture must be resorted to. The history of the insect in the Southern States indicates that it is an exceedingly difficult one to kill. Dilute kerosene emulsions are of very little use against the adults, and soaps are of practically no benefit—the insects resisting insecticide applications of all kinds very strongly. Pure kerosene, however, killed the bugs readily; but is equally effective against the plants, destroying them at least as quickly as it does the bugs. Practically, the best method of dealing with the insect has been the planting of a trap crop to attract them very early in the season and to kill off the first brood there. This trap may be either mustard or radishes, and it must be planted with the idea that it is to be sacrificed for the benefit of the cabbage or other later crop. Where early cabbages are to be set out, the field should be planted as much earlier as possible with either mustard or radishes, which will come up quickly and will be more attractive to the insects than the cabbage plants when these are put out later. When the bugs are noticed upon the trap crops, they should be sprayed with pure kerosene, which can be applied with a Vermorel nozzle from a knapsack sprayer economically and rapidly, and the application will probably kill, not only all the bugs, but the trap crop as well; so that it also will be out of the way. If desired, it can be plowed under, and this will destroy what few eggs may have been already laid upon the plants. Later in the season, when the insects attack cabbage, they are not so easily dealt with, because they cannot be readily reached by the sprays, and because kerosene is very injurious to cabbage. Mr. H. E. Weed, of the Mississippi Station, says that in his State, wherever the first brood was killed off as above described, they did not prove injurious; while elsewhere in the vicinity they were very destructive. The insects are said to be sluggish and to fly but little, remaining by preference in the field where they made their start. This lessens the danger of infection from a neighbor's field and gives the careful farmer the benefit of his applications. Mr. Weed further says that the eggs for the first brood are only occasionally laid upon cabbages where mustard or radishes are available, and that as a rule cabbages are not then attacked until the

eggs for the second brood have hatched. Where mustard is used as a trap crop, the insects can be beaten into pans early in the day. As already stated, they do not fly readily, and can be brushed or shaken from the plants without difficulty. The pan or pail should contain a little water and kerosene; enough to thoroughly wet the bugs that are put into it. This measure is perhaps a little cheaper than the direct applications of kerosene in a spray, and may be preferable in some instances.

Perhaps it would be as well to suggest here that it would be advisable not to have too many cruciferous weeds on the farm to serve as food plants for the bugs early in the season. These would furnish natural breeding-places, and would to a large extent lessen the value of any trap crop that may be put in.

REPORT OF INVESTIGATIONS ON THE SAN JOSE OR PERNICIOUS SCALE.

(*Aspidiotus perniciosus* Comstock.)

BY JOHN B SMITH, SC.D.

HISTORICAL REVIEW.

The original home of the San José or pernicious scale is as yet unknown. It was at one time believed that it was of South American origin; but later information makes it at least probable that the infested South American trees were received from California, while it has not yet been found on any native or uncultivated plants there. The species occurs also in Australia and in other Pacific islands, but it is believed to be an introduced species there also. Japan is suspected as the point of origin, but without tangible evidence. Reduced to actual fact, we simply do not know the original home of the species; hence, assuming that it is harmless there, we are without a sufficient base for sound scientific experiments with its natural enemies. We are justified, from its life history, in assuming that it is a native of a temperate clime, with a moderately severe winter, and there is absolutely nothing inconsistent with a northern Pacific coast nativity.

It was first noticed in the San José Valley, somewhere about 1870, and by 1873 had become a serious pest. It was not described, however, until 1880, when Prof. J. H. Comstock, then Entomologist to the United States Department of Agriculture, found it swarming in the orchards of Santa Clara county, and named it *Aspidiotus perniciosus*, from its destructive effect upon infested trees. Peach and pear suffered most, but all deciduous fruit trees except the apricot and the black tartarian cherry were more or less injured. It spread rapidly on the Pacific coast, and before 1892, had reached north into Washington and southeast into New Mexico.

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In the summer of 1893 the late Dr. C. V. Riley, then Entomologist to the United States Department of Agriculture, announced to the Association of Economic Entomologists, meeting at Madison, Wisconsin, that the insect had been found infesting a small orchard at Charlottesville, Virginia. At that time the source of the infestation was not known, and an accidental introduction on fruit was deemed probable. The serious character of the occurrence was recognized and radical measures were at once adopted to stamp out what was supposed to be a solitary plague-spot. Fumigation with hydrocyanic acid gas, under the direction of competent specialists of the Division of Entomology, was resorted to, and at first it seemed successful. Later on, however, it was found that many of the scales had survived the treatment, and soon the orchard was as badly infested as ever.

Additional evidence of the existence of the scale in the eastern United States prompted the issue of "Circular No. 3, Second Series," by Mr. L. O. Howard, Acting Entomologist, in April, 1894, and it was then suggested that the original source of infestation was a New Jersey nursery. This brought matters very closely home to me, and I at once began search for the nursery in fault, discovering two instead of one in a short time—the Pomona nursery, at Parry, Burlington county, and the J. T. Lovett Co. nursery, at Little Silver, Monmouth county. Letters were sent to all parts of the State, and personal visits were made to the chief fruit-growing districts, but no other infested nurseries were found at that time. Nor is there at present any other infested nursery having more than a limited local trade for special varieties known to me in New Jersey.

The Parry Brothers, of the Pomona nursery, at once realized the importance of the matter, and furnished lists of persons to whom they had reason to believe infested stock had been sent, and I secured other local lists, aggregating in all about one thousand names, of persons who might possibly have received scaly trees. The Lovett Company refused on one pretense or another to furnish similar lists, and while the managers were very courteous and gave me every chance to examine the condition of affairs in their grounds, their course, as a whole, was not one which invited confidence.

At my request, Dr. Riley sent me 1,500 copies of the circular No. 3, above referred to, and a copy of this, with an individual letter of explanation, was sent to every person who might possibly have received scaly stock. Replies to my letters came in rapidly, and proved,

to my great regret, that the scale was generally distributed through all the counties south of the red-shale line, while, curiously enough, north of that point no case of infestation has yet occurred. Meanwhile new localities in other Eastern States were becoming known, and in almost every case one or the other of the New Jersey nurseries had sent out the infested stock.

By the irony of fate, the San José scale was brought into New Jersey as a result of the effort to secure "curculio-proof" plums. In the attempt to circumvent one insect enemy, another, far more dangerous, was imported! Japanese varieties had been looked to for some time, and in the "Kelsey" it was supposed the desired combination of all good qualities was secured. A lot of stock was imported, therefore, from California in either 1886 or 1887, and this chanced to be more or less covered with the pernicious scale. Both the Lovett and Parry nurseries shared in this experience, and in both cases the infested stock was multiplied by nursery methods. The scales were thus widely distributed in a comparatively short time, and, while the originally imported stock was found to lack vitality after the second year and was destroyed, the cause of death was not suspected. It was afterward remembered, however, that it looked "scaly." In the Lovett nursery there was a single row of bearing pear trees through the ground for fruit stock which soon became infested and carried the scale over from year to year, causing almost every block of stock set in their vicinity to become infested. I found this row of trees on my first visit to the nursery and advised its removal. When I called there a few months later, the trees were gone, but much of the nursery stock was yet infested. It was not until the spring of 1895 that the Lovett Company adopted proper measures, but at that time their ground had been practically freed. All the bearing trees had been removed and all the young stock in the infested ground had been disposed of, leaving the nursery free from all trace of this scale so far as I could find.

On the Parry farms, fruit is also grown commercially, on a large scale, while many of the varieties dealt in are, to show their quality, brought to a bearing condition. These commercial and bearing orchards early became infested, and in 1894 the scale was well distributed in them everywhere. Energetic measures were here adopted immediately. Large blocks of nursery stock were at once taken out and destroyed, everything was carefully inspected before being sent

out, and in the winter of 1894-95 caustic washes were everywhere used, while all nursery stock was thoroughly fumigated before it was shipped.

The first scaly trees were distributed from New Jersey, as nearly as can be ascertained, in 1889 or 1890, and apple, pear, peach and plum were the most usually infested. As a matter of fact, only a comparatively small percentage of the stock sent out was scaly, because a large proportion of it was grown elsewhere, by contract, and only the more valuable, fancy varieties were raised and propagated on the home grounds.

Not all the infested points in New Jersey can be traced directly to the New Jersey nurseries; but dealings among the nurserymen and tree agents are sometimes so involved that the true source of such stock is almost indiscoverable.*

Nurseries in several States are now infested, and it is not safe to purchase stock anywhere in the United States without examination.

In the summer of 1894, at the Brooklyn meeting of the Association of Economic Entomologists, the distribution of this insect was discussed, and among other things, the possibility of its being introduced on infested fruit from California. As an object-lesson, I purchased at the nearest fruit stand, on Court street, half a dozen California pears, all of them infested by the scale and some of them with young larvæ crawling about. A fruit of this character, placed on or near a plant capable of supporting the species, might easily serve for a source of infestation.

In November, 1894, Bulletin No. 106 of the College Experiment Station was issued, giving a brief history of the scale, the means of spread and the best methods of dealing with it. This bulletin was somewhat elaborated and brought up to date in my report for 1894, which was distributed in the spring of 1895. Bulletins from other stations appeared as the scale was discovered in other States, and fruit-growers all over the eastern United States were soon fully informed as to the danger and means of avoiding it.

The experience of 1895 in New Jersey was not satisfactory. New points of infestation were discovered, and in many cases the applications made on infested trees were not entirely successful. Varieties which had been supposed to be exempt proved subject to infestation, and, altogether, fruit growers were anxious and desirous of further information.

* One case has been since traced to a Maryland nursery.

During the winter of 1894-95, three New Jersey fruit-growers who had orchards infested by the San José scale attended a meeting of the American Pomological Society at Sacramento and Los Angeles, California, and they were there informed that at that time natural enemies held it in check everywhere, and that the lady-birds sent in by Mr. A. Koebele from Australia and elsewhere were doing wonders in clearing out scale insects everywhere. This sort of statement should be contrasted with the fact that, in the summer of 1894, only two or three months before, Californian pears in Eastern markets were almost universally marked by the scales. I have already called attention to the Brooklyn experience, and this could be and actually was duplicated in almost any part of the large Eastern cities. Hardly a fruit stand had pears entirely clean, and in some cases almost every pear was badly infested. Evidently, then, those Californian statements were not intended to be too literally taken.

At the meeting of the New Jersey State Horticultural Society, on January 3d, 1896, Mr. Charles Parry, one of the gentlemen who attended the California meetings above mentioned, read a paper on "The San José Scale—What shall we do to keep it in check?" in which he painted the New Jersey situation in gloomy colors, and repeated as facts the statements made to him in California. It was assumed, throughout, that the Californian results were unquestionable, and it was positively stated that certain species of *Rhizobius* and *Orocus* were the agents that had controlled the scale in that State. Some of Mr. Koebele's published statements concerning the scale-feeding habits of lady-birds were also repeated, and it was suggested that "if the Entomological Department of the State would make a systematic effort to colonize these insects in our State, there is no doubt but that in a few years it would result in the same beneficial effect that has followed their introduction into California."

I replied briefly to Mr. Parry's paper, calling attention to the fact that California could not be so free from the scales as claimed, and also that of the large number of species introduced into California from Australia only a few had survived; further, that climatic differences between California and New Jersey made it at least doubtful whether we could repeat the Western success, even if there was any such.

It was admitted, however, that there was a possibility of success, but shown that it would require personal study by an entomologist to

determine the species most effective in California and most likely to do well in New Jersey. The publications existing on this subject were not sufficiently definite to make it safe to decide without further specific information. It was determined, after discussion, to request the State Board of Agriculture to ask a special appropriation from the Legislature for this investigation.

At the meeting of the State Board of Agriculture, January 14th, 1896, in a review of the insect work of the year 1895, I stated the condition of the pernicious scale in New Jersey, and briefly discussed the possibility of introducing insects to prey upon it.

At the end of my address Mr. Emmor Roberts, of Burlington county, presented the following :

"Resolved, That this board request of the Legislature the appropriation of the sum of one thousand dollars (\$1,000), to be expended under the direction of the Director of the State Experiment Station, for the purpose of studying the habits of the San José scale, its natural parasites and enemies and the best methods of exterminating the same.

"Also for the purpose of importing into the State of New Jersey such natural enemies and parasites from other States or countries as may offer a chance of lessening or exterminating this most formidable pest. That the appropriation be made available immediately, that effective work may be accomplished during the present year of 1896."

As a result of the efforts made by the State Board and the Horticultural Society, the Legislature of the State of New Jersey appropriated the sum of \$1,000 to the State Experiment Station to make the necessary investigations and experiments, and the Director thereupon designated the writer as the person to do the practical work.

Early in 1896, Bulletin No. 3, new series, on "The San José Scale: Its occurrence in the United States, with a full account of its life history and the remedies to be used against it," by L. O. Howard and C. L. Marlatt, was issued by the Division of Entomology of the United States Department of Agriculture. This bulletin contains a list of the writings on the scale, a full discussion of its life history, an account of its distribution and the record of a long series of experiments with insecticides.

After discussing the subject of natural enemies, and especially the Californian assertions, the authors say: "The possible usefulness of parasitic and predaceous insects should, therefore, at least in the East,

not be allowed for a moment to interfere with active operations with remedies, nor blind one to the importance of the San José scale and the extraordinary precautions which should always be taken to prevent its wider dissemination."

Anticipating a favorable outcome for the application to the Legislature, correspondence was had with officers of the California State Board of Horticulture, and others from whom information as to the best points for studying the scale and its enemies in California could be obtained. When the appropriation was made I was ready to start without unnecessary delay, with a fairly well-defined idea of the territory to be covered and of the species which should be sought for.

NARRATIVE OF THE JOURNEY.

Left New Brunswick May 3d; stopped over at Washington to visit the Entomologist, Dr. L. O. Howard, and consulted with him and some of his assistants as to the best points to be visited, obtaining much information that was of subsequent use to me in California. Stopped also at New Orleans, where I visited the Experiment Station at Audubon Park. The fruit trees at this place once infested by the pernicious scale had been removed, and no trace of it was now to be found. Stopped also at El Paso and crossed into Mexico to Ciudad Juarez, examining fruit trees where possible, without finding the pernicious scale. It had been my intention to visit Las Cruces, New Mexico, in the vicinity of which the scale was doing some injury, and where an attempt had been made to introduce the Californian predaceous species; but considerations of time, of expense and of other factors involved, led to the abandonment of this portion of the plan.

Reached Los Angeles May 11th, telegraphing my arrival at once to Director Voorhees, and also to Mr. Alexander Craw, Quarantine Officer, from whom I received a reply that same afternoon, advising me to go at once to Santa Barbara.

Reached Santa Barbara May 13th, and found letters from Mr. Craw introducing me to those commissioners in the southern portion of the State whom it would be desirable for me to visit. May 14th, visited the Cooper ranch, at Elwood, with Professor T. N. Snow, and, as the result of observations made up to this point, determined that it would be impossible for me to personally collect the predaceous species

that were to be sent into New Jersey. Reasons for this determination will appear in another part of the report. I deemed it a saving of time and expense to make at this time a contract with Professor Snow to mail into New Jersey to the following persons, four sendings at intervals of a month or less, each to contain not less than fifty specimens, most of them to be *Rhizobius debilis* and the balance mostly *Rhizobius lophanta*:

Dr. L. O. Howard, United States Department of Agriculture, Washington, D. C.
 Prof. P. H. Rolfs, Lake City, Florida.
 Mr. George Stokes, Freehold, N. J.
 Mr. Howard G. Taylor, Riverton, N. J.
 Mr. E. T. Gill, Haddonfield, N. J.
 Mr. Horace Roberts, Fellowship, N. J.
 Mr. Charles K. Van Sciver, Beverly, N. J.
 Mr. Benjamin Lippincott, Cinnaminson, N. J.
 Mr. Edward Lippincott, Riverton, N. J.
 Mr. Charles Parry, Cinnaminson, N. J.
 Mr. Arthur J. Collins, Moorestown, N. J.
 Mr. John S. Collins, Moorestown, N. J.
 Parry Bros., Parry, N. J.
 Mr. C. F. Sleeper, Palmyra, N. J.
 Mr. George L. Gillingham, Moorestown, N. J.

May 15th to 18th was spent in the vicinity of Los Angeles. May 19th was spent at San Diego, returning to Los Angeles May 23d, by way of Riverside, San Bernardino, Ontario, Pomona and Pasadena.

Reached San Francisco May 24th, and remained there until May 27th, visiting points in the vicinity and people from whom information could be obtained. May 28th to 30th were spent at San José and vicinity, returning to San Francisco on the latter date.

June 1st, reached Marysville, where I remained until June 4th, on which day I returned to Sacramento and saw Mr. B. M. Lelong, Secretary of the State Board of Horticulture. On the evening of that day started for the East, stopping over at Portland, Seattle and Vancouver for such investigations as could be made at those points.

To recapitulate: My route was from New Brunswick to Washington, D. C.; to New Orleans, Louisiana; to El Paso, Texas; to Los Angeles, California. Here I maintained headquarters for one week, making side trips to Santa Barbara and San Diego, as well as to other points in the near vicinity. From San Diego went to Riverside, San Bernardino, Pomona and Ontario, covering in this way the

principal fruit districts of southern California. At San Francisco headquarters were maintained another week and side trips made to Berkeley, San José, Alameda and other points in the vicinity. From San Francisco went to Marysville, stopping over at Sacramento, to which point I again returned for the start East. The return was by way of Portland, Seattle, Victoria, Vancouver, Ottawa, Montreal, Albany and New York.

INFORMATION RECEIVED.

As the conditions existing in California were known to me only from literature, I felt that my work would be much simplified by a full knowledge of what could be told me of the localities which I expected to visit; hence I questioned freely all persons from whom I might expect information upon points that I considered important. I learned almost at once that there was a hopeless division of opinion among farmers, fruit-growers and officials upon the subjects in which I was most interested. Furthermore, I found it almost impossible to get information based upon actual observation concerning the life history of any of the species that I particularly desired to study. It was easy to obtain general statements, but as soon as they were tested by definite questions it was found that most of them were based upon impression only, and that specific observations had been rarely made. Almost everyone was able to add something to my stock of knowledge from his own experience, but it was sometimes difficult to ascertain exactly how much of the information was entirely reliable—the more as assertions from observation made by one were often as positively contradicted, also from observation, by his immediate neighbor. California has an exceedingly thorough system of rules, regulations and laws for controlling fruit pests, and spends annually large sums of money for salaries of commissioners, inspectors and other officials; but unfortunately there is some ill-feeling between rival authorities and antagonism between officials—extending in some cases to the farmers. No one institution or body commands the general confidence of all the growers, and the question of particular fitness for the work required, is not always the dominant reason for the appointment of commissioners or inspectors. Nor is the tenure of office permanent, and the result is that few of the men have anything but a superficial knowledge of the plant troubles and insects with which they are

empowered to deal. Gross ignorance was rarely met with; but few of the men have that habit of accurate observation which comes only by years of experience, and which is essential to the correct understanding of the problem of the relation of insects to each other and to their host plants. Of course, I visited men to get information, irrespective of their beliefs, affiliations or office, and as a stranger probably learned at least as much of the true condition of affairs as would be possible for anyone affiliated with a Californian party or organization. Under the circumstances, in view of the contradictory nature of the information secured, it is perhaps better not to quote the individuals from whom it was obtained, in order to avoid emphasizing antagonisms already existing, or arousing others not yet formed. Exceptions can be made, of course, in the case of those gentlemen whose positions are well known and fixed by their publications. While my principal object was to obtain information concerning the San José scale, and the insects feeding upon it, or in any way keeping it in check, the entire question of the role played by natural causes in controlling scale insects in California is of extreme interest, and particularly with reference to the predatory species introduced from Australia. First of all, to clear the ground somewhat, there is absolutely no disagreement concerning the beneficial effects of the *Vedalia cardinalis* as against the cottony cushion scale, *Icerya purshii*. There is no doubt that this insect, once so destructive, has been almost completely exterminated by the *Vedalia*. We do find that occasionally, in some localities, the scale re-appears; but a colony of the beetle sent from the office of the local commissioner, usually clears them out in a few weeks thereafter. A few of the beetles also find it possible to survive from year to year, and in many instances the appearance of a colony of the white scale is followed by the appearance of the *Vedalia* without any new introduction. So far as this one insect is concerned there is no difference of opinion; and this is the only point upon which there is not a hopeless division among farmers, fruit-growers and horticultural officials. The reasons why *Vedalia* proved so successful are elsewhere set out.

In Santa Barbara, the commissioner, Prof. T. N. Snow, is a firm believer in the efficiency of predaceous insects and parasites in controlling all kinds of scales, and the Hon. Elwood Cooper, President of the State Board of Horticulture, is equally positive in his opinion to the same effect. Mr. Cooper claims that his olive orchards were,

some years ago, among the worst infested by black scale in California. At the present time they are among the cleanest, and the difference in condition is said to be due to the Coccinellids entirely, and of these the *Rhisobius ventralis* is accredited with the chief share. Two other species, *R. debilis* and *R. towombae*, are also said to breed in great numbers here, and to be effective in keeping down the scales. The San José scale was never introduced into Mr. Cooper's orchards, but it obtained a foothold in several parts of Santa Barbara county, and has been "exterminated," according to the statements, by these Coccinellids. Only a very few specimens of each of the species of *Rhisobius* were received at Santa Barbara. Of *R. ventralis* there were only twenty, and within eighteen months or two years from the time that they were liberated, the species had increased to such numbers that they could be collected by the thousands. Up to two years ago many hundreds of thousands were collected on this ranch, and from that point distributed to all parts of the State. It is estimated that in one year, more than a million specimens were taken, proving the enormous reproductive powers of the species. In 1895, the scales had been reduced to such an extent that sufficient food was no longer obtainable for the Coccinellids, and they became reduced in numbers so that collecting for them gave very poor returns. As to the number of broods of the several species, nothing definite could be ascertained, except that they were said to breed about all the time; that they were very active, and that, during the summer, all stages could be found at all times. The specimens continued abundant until late in the season, but collecting, ordinarily, was not good until well along in May or June, at which time the beetles began to make their appearance in some numbers. There was a general agreement here that the lady-birds were responsible for the reduction in numbers of scales of all kinds. Besides the Rhisobiids mentioned, quite a number of other Coccinellids were introduced into Mr. Cooper's orchard, and some maintained themselves for a varying period. At the present time those above mentioned are all that seem to be flourishing, except the *Vedalia*, which is present where food is obtainable for it, and *Novius koebelei*, which is also a feeder upon the cottony cushion scale, but finds it possible to support life upon other species as well. *Orcus chalybeus* and *O. australasia* had flourished for some time, but seem now to have died out. From information obtained, it seems that in Ventura county, which adjoins Santa Barbara on the east, the

species of *Rhizobius* are doing equally good work. A few species of *Soymnus* also occur in the orchards here, and are supposed to be more or less effective in reducing the number of scale insects. *Rhizobius ventralis* is said to feed only upon the black scale, and upon some of the other soft scales, and prefers olive to any other tree as a home, where obtainable. *R. debilis* is said to be a much more general feeder, and able to sustain life upon plant lice as well as upon scale insects. It is supposed to be much the most rapid breeder after *ventralis*. *R. towombae* is erratic and well distributed everywhere; supposed to feed on a great variety of insects and scales. It was interesting to learn that, while millions of specimens of Rhizobiids had been bred in Santa Barbara county from the very small number introduced only a few years ago, and while over a million had been collected and distributed to other portions of California, yet Santa Barbara is even at present the only place where the insects can be collected in sufficient numbers to be distributed elsewhere. In localities where thousands of specimens had been introduced two and three years ago, tens of thousands of specimens are to be introduced this year, those sent in the previous seasons having been destroyed or died off during the winters.

In Los Angeles county there is an almost universal disbelief in the effectiveness of the Coccinellids as a sole reliance. Only here and there do growers claim that some benefits have been received from the insects introduced. While Mr. Cooper has not sprayed for more than four years past, in Los Angeles county it is found necessary to spray almost every year to keep down scale insects. Nevertheless, lady-birds do very much to keep in check the injurious species. Los Angeles county suffered greatly from the San José scale in years past, and a number of orchards were pointed out to me as having been killed by it. Others, badly injured, are now recovering. There is a uniform agreement in opinion that it was no effort of the growers that destroyed this scale. All agree that some natural causes checked the injury. It is also agreed that the scale was yet to be found almost everywhere in small numbers. Almost universally the people here credit the common, twice-stabbed lady-bird, *Chilocorus bi vulnerus*, with being the chief agent in the destruction of the San José scale. There is an almost universal agreement also that the scale had been reduced to harmlessness before any of the Australian species save *Vedalia* were introduced into California. As to the usefulness of the Rhizobiids

against the black scale and others infesting citrus trees, there is a hopeless disagreement in opinion. I was shown groves into which thousands of them had been introduced, and which were at the present time horribly infested by the black scale. I was also shown orchards into which colonies had been introduced which were at the present time comparatively free from it. Again I was shown orchards, equally free from black scale, a considerable distance away from any point at which Coccinellids had been introduced. I was informed that in Los Angeles county over one million *Rhizobiids* had been set free; that the inspectors from almost every township had collected them in large quantities in Santa Barbara county, and Mr. Scott, the ommissioner, himself had spent days in gathering specimens and distributing them in his county. There is an almost universal agreement that, while during the summer the species seem to increase and breed, and to produce some effect upon the scale, during the winter they disappear, to re-appear the spring following in very small numbers, if at all. In other words, they are not able to maintain themselves satisfactorily or to increase in Los Angeles county. The only species that can be found almost everywhere, sometimes in rather large numbers, is said to be *torwombæ*, but this does not make its appearance until well along in the season. So far as the San Joë scale is concerned, few of the orchardists believe that any of the lady-birds introduced from Australia had anything to do with reducing its numbers. All agree in saying that the scale has been a very serious pest; all agree also that for some reason the increase of the scale ceased; that it decreased almost as rapidly as it had originally increased, and at the present time nobody paid the slightest attention to it. I failed to find anyone who was willing to say that lady-birds, other than the twice-stabbed, had anything to do with the disappearance of this scale. Some claim that it was the intense heat, which at some periods during the summer seemed to kill off all the young, which was responsible for the disappearance of the scale. Others thought some disease had attacked the insect, and all agreed that nobody knew anything definitely from personal observation. I was informed by one of the inspectors in this county that all the Coccinellids, including the *Rhizobiids*, are subject to parasitic attack; that they have a number of natural enemies that keep them in check, including among others the larva of a lace-winged fly, which attacks and destroys their larvæ in great numbers. This gentlemen, who is an

accurate observer, if not a systematic one, is positive that, as between the San José scale and the Coccinellids left to themselves, the scales would retain the advantage. The San José scale begins breeding here some time in May; rarely towards the latter part of April. The Australian Rhizobiids do not make their appearance, as a rule, until after the scale has begun to reproduce. In Los Angeles county the climate is very dry, and during the summer very warm; and very hot winds during the day seem to kill off whatever young scale insects may be then crawling about. In one locality in this county the *Oreus chalybeus* has succeeded in gaining a foothold, and it seems to be of some advantage by feeding upon the "yellow scale." There are yet points in the county where the San José scale is very abundant, and twigs are occasionally sent in to the commissioner that are completely covered by it.

For some reason none of the Quarantine Officers and Entomologists to the State Board of Horticulture made any satisfactory observations on the pernicious scale during the period of its great abundance. When a really good man was obtained in the present incumbent, Mr. Crow, the San José scale problem had practically solved itself, and the real reason for its disappearance can never be positively fixed from definite observations. None were made, and all that is at present stated is an inference based upon facts that might or might not have had something to do with the matter. The one really positive point is that none of the Australian Rhizobiids had anything to do with it, because they were not introduced into California until 1892, while the San José scale ceased to be injurious in 1890.

At Claremont, Professor A. J. Cook, of Pomona College, was able to give me information about the soft scales based upon observations made by himself, but could not, unfortunately, give me any information concerning the factors in the disappearance of the San José scale. He does know that the scale disappeared before any effort was made to introduce *Rhizobius* into his part of the country, and nowhere was any effort made to colonize any specific enemies of this particular scale. In fact there never was, in this particular region, any very serious infestation. The scale appeared very shortly before the general disappearance began, and the agent for its disappearance has never been studied or observed, so far as he is aware. *Rhizobius towombae* is the same as *Soymnus lophantæ*, and this species was certainly widely though sparingly distributed in California before Koe-

bele sent it from Australia. The insect is not abundant anywhere, and could not have had any very great share in reducing the number of the scales. *Rhizobius ventralis* has been introduced as against the black scale, and seems to be doing good work in some localities; but while Professor Cook was an enthusiast at one time so far as belief in the agency of this insect in reducing the scale is concerned, yet he admits now that there is some factor, or perhaps a set of factors, at work that keeps the balance between *ventralis* and the black scale at nearly an even point. Sometimes it seems as if the *ventralis* gained the advantage; again it appears as if the scale increased as against its enemy. Elsewhere in this vicinity the same contradictory opinions are found. Some believe in the value of the lady-birds; others do not. One thing is certain: no one speaks with absolute knowledge of the reason for the disappearance of the San José scale, nor has any one bred any of the Australian species of Coccinellids for even a single season, to test their food habits. Even Professor Cook, an economic entomologist of good standing, does not pretend to have any definite knowledge in the matter. There is no sort of question that in this vicinity about as many people sprayed as relied upon the lady-birds, and, taking it altogether, those that sprayed seemed to have a little the advantage. Professor Cook has observed the fact that the *Chrysopa* feeds upon the larvæ of *Rhizobius ventralis*, and he believes that they have also some other enemy that checks their increase. At all events, there can be no pretense that the insects in this region multiply anything like they do in Santa Barbara county—they barely maintain themselves. Again, returning to the San José scale, Professor Cook has no personal observations to offer and is ready to believe that fungous or other troubles may be responsible for its disappearance.

At San Diego, at National City, and in their vicinity, the history of the San José scale is very much like that already ascertained—that is, it made its appearance, it threatened great injury, and it suddenly disappeared. No one was able to give, from personal observation, the least information as to the cause of the disappearance. It never was very abundant except in isolated localities, and what is distinctly interesting is that in this locality no *Rhizobius* was ever introduced except *ventralis*, which is not known to feed upon this scale. The Australian species, therefore, are absolutely excluded as a factor in the control of this particular species, though *lophanta* occurred spar-

ingly years ago. Washes were used in many cases, and sometimes successfully; but whatever was done or not done, the result is the same; the scale has practically disappeared, though a little of it remains everywhere. There has not been an actual extermination, but nobody pays any attention to the remnants and it is nothing to worry about. Here again was found the same contradictory evidence as to the effects of *R. ventralis* against the black scale. Some believe that they have done much good; others believe that they have done nothing whatever, while nobody has any positive observation to sustain the opinion on either side. All agree, however, that the *Rhizobius* does not increase to any marked extent; that it may become abundant locally at some time during the summer, but re-appears again the following spring in very small numbers. There never is any such increase as that which was recorded in Santa Barbara county.

At Riverside, many hundred thousand *Rhizobiids* have been distributed: *ventralis*, *debilis* (?) and *towoombae* (?), and it was interesting to find there the same discrepancy in opinion that was found elsewhere. But here, also, there was no question as to the fact that there had not been any increase in the number of specimens. In fact all agreed that it would be difficult to find any at the time of my visit, and no one pretended that there was any enormous increase in the species from year to year. Here even the commissioner for the district, a man of judicial turn of mind, did not claim that the evidence was conclusive on either side. The San José scale has been at one time excessively injurious here; entire orchards were destroyed by it, and so troublesome did it become, that the growers in a large proportion of cases simply abandoned the cultivation of the infested deciduous fruits, and replanted their orchards in citrus trees, which are not attacked by this scale. Spraying was first resorted to in many instances, and all kinds of mixtures were used; fumigation was practiced on a very large scale, but never was, in any case, attended with an absolutely satisfactory result. As the years went by the scale dwindled and gradually disappeared, so that now it is difficult to find specimens in any numbers. This was before any of the Australian *Coccinellids* had been introduced; but everywhere there was an agreement that about the time the scale began disappearing, there was an enormous increase in the numbers of the twice-stabbed ladybird. The inference was that this, if anything, was responsible for the disappearance of the scale. The remedial measures that were

found most successful were the resin washes, one or two patented formulas, and the "wood-pile." Mr. Havens, the commissioner, was very conservative. He does not believe that the San José scale was destroyed by parasites alone; yet he believes that they, or predaceous species, had much to do with it. He knows that the Australian *Rhizobiids* were not of the agents, because they had none at that time. As to the black scales, they seem everywhere less abundant this year, whether the orchards have or have not been colonized with *R. ventralis*.

In driving from Ontario through the Chino region, met Mr. James W. Mills at the Branch Experiment Station. Mr. Mills is from the Sacramento region, and said that in his locality the San José scale threatened serious injury for a time. The growers saw ruin staring them in the face, and went into the spraying business on a large scale, building steam boilers in some instances, by means of which the mixtures were made in large quantities. Spraying was done thoroughly and continuously with great success, almost ridding the orchards of the scale. Wherever it was noticed, applications were made promptly and thoroughly, and the success was such that in some localities it was entirely stamped out. Later, it was noticed in several places that it seemed to be disappearing from natural causes, and since then there has been no serious trouble, so far as he knows. What the natural causes were, he could not pretend to say, and has never found anyone who could. The Australian lady-birds were not concerned in this case; they had never been, so far as he knows, introduced into the localities at the time the fight against the scale was on.

Throughout this Ontario region, thousands upon thousands of *Rhizobius ventralis* have been colonized in the three years last past. Not only have the commissioners distributed them in enormous numbers, but individual growers had themselves collected great quantities in Santa Barbara county, and had introduced them into their own orchards. Everywhere, it is admitted, the black scale is still present in very large numbers, and everywhere, it is admitted, there has been no increase in the lady-birds. In fact, there is an almost universal agreement that they had nearly, if not quite, died out in most places. Yet it is planned, for the season of 1896, to introduce at least ten thousand each month, to test more systematically than has been done heretofore, the possibility of securing an increase of the species in this region. Here, again, the testimony seems to be that

there is a natural variation in the quantity of black scale from season to season, irrespective of the introduction of predaceous insects; that is to say, some years the scale is very abundant and very troublesome. In others it is comparatively rare and seems to be disappearing. This variation occurs as well where no predaceous insects were ever introduced against it, as where the largest colonies were planted. Here the testimony in favor of spraying becomes much more positive than at any point heretofore visited. It is claimed for the lime, sulphur and salt wash that it will positively clear trees when thoroughly applied. Here, also, the San José scale is yet present in numbers sufficient to make spraying desirable, and here, too, there is no reliance upon natural enemies. As to this particular species, no one with whom I spoke seems to believe in the efficiency of the natural enemies. According to the stories told, the year 1890 marked the time when the scale gradually lessened in numbers and soon after, in some localities, disappeared entirely. No foreign Coccinellids had been introduced into the region at that time, nor were any introduced until some years later.

At Pomona, I called on Professor H. C. Fall, a good collector and an excellent entomologist, making a specialty of Coleoptera or beetles. While Professor Fall does not pretend to make any study of the economic side of the question, he has collected carefully everywhere. He does not believe there is the slightest chance of the foreign Coccinellids doing any permanent good. He has collected closely and never gets anything but *Rhizobius ventralis* and *lophanta*. The latter species was collected by him in the cañons, before Koebele sent it from Australia in 1892, and is there more abundant than anywhere in the orchards. *Soymnus marginicollis* is a native species, which is easily mistaken for *lophanta* by the ordinary observer. He has never taken *debilis*. He says of *lophanta* that it is certainly acclimated now, and stands on the same footing with the native species. It does not seem to favor orchards particularly, and he thinks it will not remain there in preference to uncultivated regions. *Ventralis* he had found, but never commonly or in large numbers at any time. He believes that *Soymnus marginicollis*, which occurs in orchards in some numbers, is the species that is also generally mistaken for *Rhizobius debilis*. If that species, i. e., *debilis*, has ever been introduced, as is claimed, it certainly has disappeared, and he has never found a specimen. Professor Fall takes no stock in the claims made for the

Coccinellids as against the injurious scales. Further investigation in the vicinity of Pomona produced much the same accounts that I had been hearing for several days past: enormous numbers of Rhizobiids, liberated in some orchards, where, at this time, scarcely a specimen could be found. The San José scale is rare in this region at the present time; but I find many people crediting persistent work in spraying with this result, rather than natural causes. Again, others believe that some mysterious disease or parasite is responsible for the work, and again it is here quite positively stated that the scale began to decrease in 1889 or 1890, before any introduced species were found in this particular region. There is some of the pernicious scale about everywhere, and spraying against the remnants is generally practiced. No dependence is placed upon predaceous insects or parasites at the present time. The resin wash is here the favorite, but no one believes that a single spraying with any mixture ever proves successful. Again I found evidence, positive in character, that tens of thousands of specimens of *Rhizobius ventralis* have been liberated in recent years and definite statements that no success has attended this introduction. In some comparatively small orchards, where thousands of specimens were liberated, nothing could be found of them a few weeks afterward, and in the season following not a specimen could be collected. Here, also, I met positive statements on the part of one of the inspectors, that since spraying has been generally stopped, in order to give *Rhizobius ventralis* a clear field, the black scale has increased in number and in general destructiveness. As to the San José scale, this inspector ridicules the idea that any of the foreign Coccinellids had anything to do with it, while he admits that *C. bivulnerus* may have been an important factor. He is also inclined to attribute considerable importance to the internal parasite, *Aphelinus fuscipennis*. At the present time no dependence is placed upon natural checks to control the scale, but spraying is everywhere practiced whenever it is noticed that it seems inclined to become troublesome. The resin washes are believed to be most satisfactory, and it is insisted that they must be very thoroughly boiled to produce the most satisfactory effect. No farmer ever depends upon a single application for complete success. No dependence upon parasites or predaceous insects, prompt spraying and eternal vigilance are believed to give the best results. One interesting experiment was shown me where no poisonous application has ever been made, and here the

scale has maintained itself in about equal numbers from year to year, and has rather increased than otherwise, in spite of the enormous introduction of supposed Rhizobiids other than *ventralis*. One of the best observers in this region, judging of his ability from what he showed me, says positively that in that particular section the Rhizobiids do not, and never will, succeed in coping with the black scale, and as to the San José scale, it would be criminal folly to rely upon the natural enemies.

At Pasadena it is believed that good results have been observed from the introduction of the Rhizobiids. It is thought that they are of great benefit in reducing the number of black scales, that they are effective against the San José scale and that they have caused its disappearance in that immediate vicinity. It is admitted, however, that they do not control the red scale, which belongs to the same genus as the San José or pernicious scale, and the evidence is rather in favor of their effectiveness against the black scale than to any other end.

At San Francisco, Mr. Craw placed at my disposal all the information secured by him or on record in his office. Mr. Craw has taken no uncertain stand in this matter, and he is positive in his belief in the usefulness of parasites and predaceous insects in general and in the value of the Rhizobiids in particular. Mr. Craw cited case after case of orchards into which *Rhizobius ventralis* had been introduced, with the result that the black scale had been either lessened or exterminated, and he is enthusiastic in his belief that this species will yet obtain control of that scale within the entire State. Mr. Craw admits, however, that nowhere within the State has there been an increase in numbers that is at all comparable with the enormous increase noted at Santa Barbara. He admits that in many places where it has been introduced it has, seemingly, died out. He claims, however, that it has established itself in a very large number of instances, and that good results are appearing and will continue to appear. Nevertheless, none of the localities produce any such numbers as seen at Santa Barbara, and, more recently, in Ventura county. He explains that often, where the insect has failed to establish itself, or to do good work, no sufficient time was allowed it; that within a few weeks or months after the introduction, spraying was resorted to, and the Coccinellids were destroyed with the species against which the application was made. A very important statement on Mr. Craw's part is that, where these predaceous insects are relied upon, no spraying must

be done, as otherwise there is more danger to the parasites and predaceous insects than there is to the scales. Concerning the specific question of the San José scale, Mr. Craw is less definite than on the other point—that is, the *Rhizobius ventralis* against the black scale. He claims, however, that the disappearance of the scale was caused by the combined action of *Aphelinus fuscipennis*, *Chilocorus bivulnerus* and *Rhizobius towombæ*. This latter species, he admits, has been in the country for many years, and was probably an accidental introduction long before Koebele sent it from Australia with the *Vedalia*. He is very positive that these species are responsible for the benefits received, wherever he observed them, and is not inclined to admit the existence of any other large factor in the disappearance of the pernicious scale. He attaches a great deal of importance to the *Aphelinus*, which in some localities, he believes, has done the best work. Mr. Craw is positive that he has seen a large number of scales on individual trees that had been parasitized, and that on others he found very large numbers of the Coccinellids referred to, apparently feeding on them. No systematic effort was ever made to study the question of other possible factors in the disappearance of the scale.

At Berkeley, Professor C. W. Woodworth, the Entomologist of the Experiment Station, gave me much information on the general subject of predaceous insects and parasites, and his stand is the exact opposite from that taken by Mr. Craw. He believes that predaceous insects and parasites are a very small factor in the disappearance of scale insects anywhere. Concerning the San José scale he disclaims personal knowledge; but is distinctly skeptical as to the important part said to have been played by natural insect enemies of the scale. Concerning the *Rhizobius ventralis* and its effect, he has very definite opinions, and these are published in a report of the Stations of the University of California for the year 1894-95. As Professor Woodworth is a trained entomologist of good standing, who has made this a careful study, his opinion is to be considered of much value, and is to be given especial weight as against statements made by less competent or untrained observers. On page 258 of the report above mentioned, he says:

“Parasites take some part in the destruction of the black scale. The common native Chalcid is estimated, by Professor Howard, to destroy 75 per cent.; but this only means three out of four of those that came to adult size contained the parasite; that is, less than 1 per

cent. of those hatched. I have never known of a case where more than 2 per cent. were destroyed from this cause. The other 98 per cent. met some other fate. * * *

"The number ordinarily destroyed by lady-birds is much smaller than is usually supposed. Lady-birds and their larvæ are to be met with more abundantly in other situations than in scale-infested trees; indeed it is the exception to find them particularly abundant on such trees. On the university grounds, in Berkeley, the only case of particular abundance of lady-bird larvæ on a tree infested by any kind of scale insects, which has occurred during a period of five years, was a carob tree infested with the greedy scale, which had for two seasons a great many 'twice-stabbed lady-bird' larvæ, and which is still scaly. The fact is quite observable that the beetle of the *Rhizobius ventralis* feeds by choice, if not entirely, on the diseased larvæ of the black scale; and it is also true that the whole family are closely allied with, and doubtless derived from fungus-eating beetles. So it may be that the lady-birds only do well on insects made palatable by the attack of certain bacteria or fungi.

"Whatever may or may not be the merits of the lady-birds, the fact remains that the great majority of these insects are destroyed by disease; that is, with the present adjustment of nature, the diseases are, practically, the only things capable of maintaining the present balance. A very slight variation in the degree of virulence of the diseases would entirely change the per cent. of scale insects on a tree, or in a section of country. The almost entire destruction of the scale by disease is a matter of not infrequent occurrence. * * *

"Another scale insect, the well-known *Ioerya*, having been so thoroughly destroyed by the Australian lady-bird, *Vedalia cardinalis*, many have believed that an equally effectual remedy could be found for the black scale. Such a search was well worth inaugurating, but the promise of results, as well recognized by entomologists generally, was by no means as good for such an insect as the *Ioerya*. The egg-case of the latter insect presented a particularly vulnerable point of attack. The State very properly made a good appropriation for the purpose; the services of Mr. Koebele were secured, and no effort was spared to make his work a success. There were imported, according to the reports of the State Board of Horticulture, no less than sixty species of predaceous and parasitic insects. Of this number only one has appeared to at all justify the expectations of those believing in the general efficacy of this means of destroying insect pests. This is the now famous *Rhizobius ventralis*. A few pairs of this insect, about twenty specimens, were received by Mr. Cooper, the President of the State Board of Horticulture, in May, 1892, and placed in his olive orchard near Santa Barbara. In December of the same year, Mr. Koebele visited this orchard and found the insect doing well, and plentiful in all stages of development. The next year they increased very rapidly, and were reported to have practically stamped out the

black scale. During October of that year, four hundred and fifty-three colonies, representing fifteen to twenty thousand insects were distributed all over the State. The black scale, however, remained fairly abundant on Mr. Cooper's place, for in 1894 a large number of the *Rhizobius* was said to have been distributed from there, and there is said to be still some black scale in his orchard, though the *Rhizobius* is much less numerous.

"There is no doubt that there was a great decrease in the abundance of black scale, associated with a great abundance of the *Rhizobius*, in the case of Mr. Cooper's orchard. This is conceded on all hands. The general question of the effectiveness of the *Rhizobius* is one, however, which has stirred up a greater amount of discussion and has produced more heated partisan feeling than has ever been the lot of an insect to occasion before. The importance of the subject is such that the writer has given it considerable attention, and has twice visited and carefully gone over the ground about Santa Barbara and in other parts of the southern portion of the State. There seems to be no question but that the *Rhizobius* does destroy a certain number of the black scale. The *Rhizobius* has also become thoroughly well acclimated in the region about Santa Barbara and in a number of other points in the State.

"It is a fact that the *Rhizobius* has been present in trees in which there has been a notable decrease in the abundance of the black scale, but it is also true that it has been present in about equal numbers, at the same time, in neighboring trees in which there was no decrease in the black scale. It is incontestably the fact that, in the city of Santa Barbara, where the *Rhizobius* has been allowed to have its own way, and where it has been very abundant for more than a year, there is to-day a larger amount of black scale than at Berkeley, where there has been no spraying for three years and where the *Rhizobius* has not been able to secure a foothold. The black scale does not do quite as well at Berkeley perhaps as at Santa Barbara, but I have seen some trees here that were as badly affected as any I have met with anywhere.

"Almost every case investigated, where wonderful results were claimed for the *Rhizobius*, proved that, though the *Rhizobius* may have been present, it could have been only an extremely small factor in the results obtained. There are a few cases where there was an exceptional abundance of the *Rhizobius*, accompanied by a striking decrease of the scale, but there are more cases of an equal decrease in scale without the exceptional abundance of the *Rhizobius*."

The final conclusion of Professor Woodworth on this subject is important. He says: "Taking all the evidence, it appears that the *Rhizobius* is scarcely, or not at all, more efficacious than the native lady-birds, except, perhaps, being slightly less omnivorous."

This is the deliberate conclusion of the only trained entomologist who has ever investigated this subject systematically in the State of California.

Professor E. J. Wickson, of the same Station, believes that *Chilocorus bivulnerus* was the insect agent most concerned in the destruction of the San José scale wherever it disappeared without active measures taken against it. He claims little personal knowledge on the subject, and has made no systematic or definite observations, but has gained that belief from the testimony and observations of others, repeated to him.

Concerning the source of the pears badly infested with the San José scale that are annually sent to the Eastern market, Dr. E. W. Hilgard, the Director of the Station, and Professor Wickson, agree that it is probably the Sacramento Valley region. Neither of them believes in an extermination of the scale; but both admit that in some localities natural causes have done much to reduce it in numbers, but just what those natural causes are, they were not willing to say.

At San José I had an opportunity to go over some of the ground that years ago was the worst infested. Saw some of the orchards, or rather the remnants of them, where the scale had been most abundant, and saw some of the people who had fought it at great expense. Even here it was impossible to obtain direct evidence as to the agent most concerned in the reduction of the scale. There is some present everywhere, especially in old orchards, and in such localities *Chilocorus bivulnerus* is excessively abundant and undoubtedly feeding on the scale. In this region the growers seem to be inclined to attribute the disappearance of the scale to the internal parasite *Aphelinus* and the *Chilocorus*, while *Rhizobius* is nowhere credited with more than a very subordinate part. Concerning the *Rhizobius ventralis* against the black scale on deciduous trees, it is considered a flat failure in most instances. It was impossible for me to get any satisfactory information in this region concerning the breeding habits of the scale, or of the parasites, and statements made by the growers are contradictory. Nevertheless, I obtained from Mr. E. M. Ehrhorn, the Commissioner for Santa Clara county, the results of some accurate direct observations, which enabled me to formulate more definitely my opinions as to the way in which the scale became so reduced in numbers in this part of the State. In this region *Rhizobius ventralis* has been introduced several times, sometimes in large

colonies, and in some cases colonies have been introduced in successive years; but there does not seem to be any perceptible increase in the lady-birds, and certainly there is no perceptible decrease in the number of black scales.

In the vicinity of Marysville and Yuba City, I can find scarcely anybody who is willing to credit natural enemies with having had any effect on the San José scale. It has been, in the past, exceedingly destructive, and it still is, in many localities, a pest that must be reckoned with. Some orchards are yet quite badly infested with it, and, particularly in new fruit regions, it is increasing in number, although it has not become sufficiently injurious there to threaten the life of the trees. In other words, the scale is moving into new districts and increasing in numbers in those new directions. Almost every grower with whom I talked—in fact, I can say, every grower without exception—has used and still continues to use sprays, and here the lime, sulphur and salt wash is the favorite. The testimony to its efficiency is universal and uniform. Few claim that a single spraying is absolutely effective; all contend that two spraying will kill practically all the scales. Absolutely perfect work cannot be expected, and so there is always a small amount of scale in the orchards; but as they have found that the use of this wash is beneficial to the trees by seeming to make them more vigorous, less liable to fungus attack, and, in the case of peach trees, less susceptible to leaf curl, the spraying is continued every year, or every other year, whether the scale is abundant or not. In this region, Yuba and Sutter counties, there are thousands of acres of deciduous orchards, and those orchards are almost universally sprayed. A man who does not spray is considered a very poor farmer. Here are some extensive plants for the manufacture of the wash, and one of these I had the pleasure of seeing on the farm of Mr. Harry P. Stabler. Mr. Stabler, when his orchards were threatened with extinction by the scale, put in a steam boiler and two huge tanks, obtained two large "Bean" pumps, each capable of supplying two lines of hose, and went to work systematically to exterminate it. He spent a large sum of money in doing the work; but he conquered the scale, and his orchard is to-day as free as any in the State. There can be no sort of pretense that in this region the lady-birds have been a factor in the disappearance of the scale. Spraying is done everywhere, and has been done for years. Spraying, according to Mr. Craw, is fatal to the success of the lady-birds.

Spraying and cultivation as done in this vicinity are as thorough as it is possible to imagine, and the result is practically uniform. A great deal of stress is laid here upon the proper mixture of the materials. The wash is said to be effective in proportion to the time of boiling it; the shorter the time the less the effect, the longer and more thorough the boiling the better the effect. There never was any general introduction of either parasites or predaceous insects into this region. Individual colonies were introduced, but they seemed to disappear shortly afterward. At all events, the record is clear as to some of the orchards that were badly infested. In Mr. Stabler's case, two hundred acres were thoroughly infested by the scale; spraying was done thoroughly with the lime, sulphur and salt wash two years in succession, and the scale was in that way almost exterminated. Predaceous or parasitic insects were not a factor here, and the same I believe to be true for the whole of this region.

PERSONAL OBSERVATIONS.

I have thought it well to set out first the fact that there is no agreement in California concerning the part played by the predaceous insects or parasites in the destruction of the San José scale. It is important to note that there never has been any systematic study of this matter, and that no one has followed, for even a single season, this scale and its natural enemies, so as to be able to speak from personal knowledge. My own stay in California was altogether too brief for any systematic series of observations. Nevertheless, I believe that I did see sufficient to enable me to explain why the scale has, in some localities, disappeared from natural causes, and why, in others, these causes were less effective. There is no doubt in my mind, from my own observation, that in southern California—using that term to include the region south of San Francisco—natural causes have resulted in the practical disappearance of the San José scale. Further, there is no reasonable doubt that north of that point natural causes have played a very inconspicuous part, and this is easily proved by the fact that wherever we have neglected orchards we have plenty of scale, and yet in neglected orchards natural causes might be supposed to be the most effective, because undisturbed. In the first place, there can be no pretense that the scale is "exterminated" anywhere in California. I found it in every locality visited

by me, admittedly in small numbers, except north of San Francisco. At Santa Barbara, I found it everywhere in the vicinity of the city, wherever I chose to look for it. At Los Angeles there was plenty of it scattered here and there, sometimes in considerable abundance, but usually only in small quantity, and so of all other localities.

A very important point is the period at which the scale begins to breed, and as to this I was able to get very little definite information. Most of the growers seem to believe that it breeds all the year around. Mr. Craw writes me that "our time for hatching is about the same as yours; that is, the principal hatching takes place the end of May and early in June," and this agrees with my own observations. At Santa Barbara I found, May 13th, the larvæ just beginning to hatch, and a few of the young scales already settling upon the little twigs and on the fruit of apple trees.

At Los Angeles, May 11th, the larvæ were observed in considerable numbers, and quite a number of them were already set, but most of them still white and apparently not to exceed a few days old. At Santa Barbara and at Los Angeles I noticed everywhere an almost incredible number of *Chilocorus bivulnerus* in all stages. There were any quantity of beetles, and larvæ were running about by the hundred. Some of them were pupating, some had pupated, and some beetles of the second (third ?) brood were beginning to issue. A week later, at Los Angeles, beetles of the second brood were enormously abundant, and eggs for the next brood of larvæ were generally scattered over the trees. This insect was everywhere in evidence, and everywhere it was feeding on scale insects. I found here, in examining the pernicious scales, that there was quite a large proportion beneath which the insects were dead; that is to say, the scales had not been punctured by parasites; the insects beneath them had not been injured by predaceous foes, yet nevertheless they were dead, and without having reproduced. The percentage of parasitized scale observed was very small, in no case more than three or four per cent. on any of the twigs examined.

Between Los Angeles and Pasadena there are no very large orchards and comparatively few deciduous trees. But almost everywhere, where a few apple or pear trees were still to be found, they were more or less infested by the San José scale, and everywhere I found that same appearance, i. e., a very great number of *Chilocorus* and a very

large proportion of dead insects beneath the scales, but nowhere did I find any large proportion of parasitized scales.

At Santa Barbara I looked very carefully for *Rhizobius* on the trees infested by the Santa José scale, but found no trace of any of them in any stage. On Mr. Cooper's ranch, at Elwood, everything certainly looks good. There never was any San José scale here, but so far as black scale is concerned, it was said to have been one of the very worst in the State. Many olive trees yet showed the effects of the black scale, and, in fact, scattered everywhere throughout the orchards, there is considerable of it yet present: not enough to hurt anything anywhere, but it has not been by any means "exterminated." In one orchard toward the entrance there is indeed a very fair degree of infestation, yet everywhere everything is in full bloom and promises a very heavy set. So badly had the orchard been infested in the past that, it is said, the trees had ceased to bear fruit; but there is no doubt that at the present time the trees are looking as healthy and vigorous as could be desired. Mr. Cooper's ranch was of particular importance and interest from the fact that here the species of *Rhizobius* and particularly *ventralis* obtained the first start, and it would be impossible to select a point better situated for the propagation of insects of almost any kind. The climate is remarkably even, the ranch is well sheltered from winds in every direction, there is an abundance of shelter in the wooded cañons still forming part of the farm and in the everlasting olive foliage, and altogether there is a combination of natural surroundings in this location that I have not found duplicated anywhere else in the State. I visited this place in company with Professor T. N. Snow, who had collected here hundreds of thousands of specimens and who was well acquainted with the locality. Yet, after considerable search, not a single *Rhizobius debilis* nor *Rhizobius towombæ* could be discovered, nor were any larvæ beaten down. Both Mr. Cooper and Professor Snow were confident that a little later in the season there would be any number of them; but it was a very important point for me to settle, that on May 14th, in the almost perfect climate of Santa Barbara, these insects had not yet made their appearance on the trees, and had not yet begun to breed after the pernicious scale had begun to multiply. At the present time, the species of *Rhizobius* are all that are found of the introduced species on this place, and these are the only ones that can be accounted a success so far as becoming acclimated is

concerned. It is said that in former years they could be gathered earlier in May, but there is no claim that they ever made their appearance before that month. As the difference in climate between California and New Jersey must be taken into consideration in any scheme for introducing insects into the latter State, the date at which they make their appearance in California is an important one. A few specimens of *Scymnus* were beaten from the trees, but not more than a dozen in all from the score of trees tested. Certainly there was no chance here for getting a single colony in an entire day's work. It is said that when once they do appear they increase very rapidly and do satisfactory work; but it was plainly impossible for me to remain at Santa Barbara long enough to gather the necessary insects to be introduced into New Jersey, with the sum of money at my command, and I therefore arranged with Professor Snow for making collections when the specimens became more abundant, later in the season.

May 16th was entirely devoted to a study of the appearance of orchards infested in the past, near Los Angeles and between that point and Pasadena. During part of the day Mr. George Compere, chief inspector of the district, acted as my guide, and I believe that I obtained through him a very good idea of the condition of affairs in the vicinity. Everywhere the San José scale is still present, but usually in small numbers only. Everywhere, also, *Chilocorus bivulnerus* occurs in immense numbers. Again I had the opportunity of verifying my observation of dead insects beneath scales on comparatively new growth, so that it was not possible to believe they had been in that condition for a series of years. In some cases there was an appearance as of a fungus; but this may not have been the cause of the death of the scale. In this region nothing except *Rhizobius ventralis* has been introduced, and this, it is said, never feeds upon the San José scale. *Rhizobius lophantæ* is sometimes found in numbers; but the introduction of this species was unintentional, and the insect has existed for many years. It is never anywhere nearly so abundant as the *Chilocorus*, and as a matter of fact I failed to find a single specimen. In one orchard I found *Orcus chalybeus*. Quite a number of beetles were seen, and a great many egg patches were discovered, which Mr. Compere said were of this species. This would indicate that later in the season the species would increase considerably, and I was promised several colonies for New Jersey. The insect is credited with feeding upon the armored

scales in general. No *Rhizobius lophanta* were collected at any point during the day in any stage.

At Claremont and in its vicinity, citrus orchards are most common; but there are many apricots and prunes as well, and everywhere there was an abundance of black scale. The San José scale had never been very numerous in this locality, and no special measures had ever been taken against it. Under the guidance of Professor A. J. Cook, of Pomona College, I drove through a portion of this district without seeing anywhere any San José scale. Large numbers of *Rhizobius ventralis* have been introduced, and sometimes during the summer they are said to be present in considerable numbers. It is believed that they are keeping the black scale in check, but practical observation shows that they are still a very long way from having exterminated it. Judging from the appearance of the trees, the scale could not have been in the past much worse than it is at present. No larvæ of the *Rhizobius* were observed upon the trees, nor in fact were any beetles seen; but no particular search was made at this time. The only insects that were at all abundant on superficial examination were species of *Psocus* and the larvæ of *Chrysopa*. Of the lady-birds commonly found here, *Chilocorus bivulnerus* is by all odds the most abundant.

At San Diego and at National City, a large proportion of the ground was newly planted, and the region is, taken as a whole, quite free from scale insects. In the olive orchards the black scale is abundant everywhere. Of San José scale there is nothing that I could find at the present time. There never was much anywhere, according to the statements made to me. During the time it was present some made use of sprays with more or less success, but most did nothing, and the insect disappeared again without the cause having been noted. Again the twice-stabbed lady-bird was everywhere abundant. *Rhizobius ventralis* has been introduced into this county, but not in any very large quantity, and I could see no difference between localities where it had been colonized and places where none had ever been received. There was just about the same amount of black scale in every instance. A very few specimens of *Rhizobius ventralis* were found by beating, but nothing like the number which would be necessary to make an impression upon the scale.

At Riverside the citrus industry has replaced the deciduous fruit trees of the past, the San José scale having driven out the fruits

infested by it. At the present time the trees are everywhere badly infested by the black and other soft scales, and this region was a particularly interesting one, because of the enormous quantities of *Rhizobius ventralis* that had been introduced into it. One orchard shown me, in which several thousands had been liberated, certainly indicated reduction of the black scale from some cause. Scarcely more than five per cent. of the scales examined were alive; but as to the cause of death, there was nothing to indicate that *Rhizobius* had anything to do with it, because there was no apparent injury to the scale itself, and there seemed to have been rather a drying up than an eating out. It is much like the appearance that Professor Woodworth considers the result of fungus attack. Two or three *ventralis* were found after some beating; but no larvæ. The insects that had been introduced here were mixtures of *Rhizobius ventralis*, supposed *debilis* and *towombæ* and such *Soymnids* as were collected with them. In a near-by orchard, where no *Rhizobius* had ever been introduced, there were no more scales than before; but here nearly everything was alive, less than five per cent. of the scale being dead, the condition of affairs as between the two being exactly reversed. Furthermore, a third orchard was found in which several thousand of the *Rhizobiids* had been liberated, and there was, comparatively speaking, no difference between it and the one previously examined; that is, most of the scales were alive and certainly less than 10 per cent. of them had been killed from some cause or other. There was practically no difference between the second and third orchards examined. Among the dead scales found here, quite a number had been parasitized by a Chalcid, so there was very little evidence that the *Rhizobius* had been of any direct benefit. Yet further off, at some distance from any colonized orchard, was one that had been quite badly infested and where no beetles had ever been introduced. Here fully 80 per cent. of the scales were dead, and of the dead scales very few showed signs of having been killed by parasites; but most of them appeared to have been killed by some disease or other similar cause. The last orchard examined of olive trees certainly seemed to show the beneficial effects of either *Rhizobius* or other predatory species. This grove of trees, it was said, had been very badly infested by scales, and judging from the appearance of the old leaves and of the branches, this must have been the case. At the present time the scale has been reduced to a very insignificant figure. No *Rhizobius* were found at

this time; but it is said that specimens were abundant enough during the summer. It is worthy of note here that wherever the evidence that *Rhizobius* has been useful is strongest, it is found that an olive grove has been the point of introduction. Mr. Cooper's trees are largely olive, while the citrus ground is small, and of no commercial importance, and other places where the benefit apparently derived from *Rhizobius* has been greatest, are all olive orchards. This has been explained by the fact that in such trees the beetles find greater opportunities for shelter and concealment than elsewhere, and possibly this may be so; but it would seem, therefore, that the beetles would scarcely do well in localities where such shelter is unavailable. That this is probably the fact seems to be proved by the statements made where deciduous fruits are chiefly grown, for here the beetles are said to be of no use whatever against the black or other soft scales. Near Riverside, as already stated, the San José scale had practically driven out the deciduous fruit trees, such as apple and pear; but where the trees were not taken out and were left to themselves, the scale gradually disappeared; the disappearance being accompanied by an enormous increase in *Chilocorus*. There never was any attempt to introduce *Rhizobius* as against this scale, and long before any were found in the district, the San José scale had disappeared and the black scale had taken its place. It is another point worthy of note that throughout this district the black scale seems now to be much less abundant than it has been in the past, irrespective of whether *Rhizobius ventralis* has been colonized in the vicinity or not.

In the vicinity of Ontario I found that spraying was the chief reliance as against the San José scale. Here there were several points where it was still to be found and more places where it had been quite abundant recently. All such places had been sprayed with the lime, sulphur and salt wash, and this seems to have been effective. The practice here is to spray promptly whenever the scale is noticed increasing anywhere. There is no reliance upon natural causes to keep it in check, although natural causes, whatever they may have been, are credited with having reduced it in the past from the rank of a first-class pest to its present unimportant state. Citrus orchards prevail, and quite a number of them were visited. The black scale is abundant everywhere, and everywhere it was said to be "not as bad as it had been." In this respect, there was no difference between localities that had been colonized by *Rhizobius ventralis* and those that had

not been colonized. Tens of thousands of the beetles have been placed in this township, sometimes several thousands in a single orchard, and during the day I found just one orchard where specimens of the beetle and a few specimens of the larvæ could be found. Everywhere else they seemed to have disappeared entirely. Nobody pretends that there has been any increase, and the best that can be said is that they have not entirely died out. It is very certain that, considering the immense number of lady-birds that have been colonized in this vicinity, there is little or nothing to show for it. I saw here some loquat trees infested by the pernicious scale, and again noticed that the insects were beginning to reproduce; larvæ were found on the trees in great numbers and freshly-set scales were abundant everywhere. Yet, somehow, it seemed to me that the scales were not nearly so vigorous and the larvæ not nearly so abundant or active as under similar circumstances in New Jersey. Several places yet infested by the scale were visited, and in every instance the impression just stated was intensified. That is to say, they seemed to be of comparatively low vitality, and there were many dead insects beneath the scales, where no trace of either parasites or predaceous insects could be observed. No species was ever introduced into this locality for the special purpose of preying upon the San José scale, and whatever the natural causes that subjected it, they were not such as were provided by man. There is not the slightest evidence that any *Rhizobius* had anything to do with it.

At Pomona, I examined an olive orchard, in which many thousands of the beetles had been liberated, the owner himself having collected them at Elwood, and personally brought them into this orchard. Here, it was stated, a few beetles could always be found, and sometimes during the summer quite a lot of them could be seen. On May 22d, when I visited the orchards, not a larva nor a beetle could be seen anywhere, nor did beating have any better result; not a specimen was found. Scales were quite abundant throughout the orchard, but not in sufficient numbers to cause any serious injury. The owner thought there were not so many as there had been in the past, and he believed that some reduction had been effected. I found that internal parasites had been at work here, many of the scales showing the holes from which the minute wasps had emerged; and I found also, on these very trees, enormous numbers in all stages of *Chilocorus*. These were then actually feeding upon the black scales, and it seemed

to me that they were present in sufficient numbers to account for whatever reduction was observed. It is certain that at the present time there was not *Rhizobius ventralis* enough in the orchard to make any impression upon the scales, while it is equally certain that there was plenty of the *Chilocorus*. In no case did I find that all the eggs beneath a scale had been devoured, even when the scale had been plainly eaten into. In this vicinity, I can find some San Jo   scale scattered about everywhere. Sometimes a single tree in an orchard becomes infested, and usually, when such is discovered, the inspectors order it to be sprayed; not only the infested tree, but those surrounding it being marked for treatment. During the afternoon, I was driven to several orchards very badly infested by black scales, and in which thousands of *ventralis* had been liberated by the gentleman who acted as guide. There was certainly no evidence that any good had been accomplished there. The term "thousands" has been used so frequently in speaking of colonies of *ventralis*, that it may be as well to explain that after the astounding increase of this species on the Cooper ranch, and the apparent good work that was done there, commissioners and inspectors from all the infested districts went to Elwood to collect specimens, and many owners of large orchards did likewise. So abundant were these creatures that two or three days' collecting, which was sometimes done, resulted in filling from a dozen to twenty quart jars with as many beetles as could be comfortably accommodated, and several hundreds could sometimes be housed in a single jar. Tapping a branch would often result in from twenty to thirty specimens dropping into the cloth held beneath it, and hence what may be justly termed "enormous" numbers of the beetles were introduced into some orchards. So far from increasing anywhere in this district, there is no doubt that they have decreased to a very insignificant number, and while they may become more abundant during the summer, some factor which has not been observed, reduces them during the winter, so that a very few only survive; and this factor, whatever it is, is so potent that it would almost undoubtedly result in the extermination of the species were it not annually renewed. As to the San Jo   scale, the only insects that feed upon it, so far as I could observe, were the *Aphelinus*, traces of which were seen everywhere, and the *Chilocorus*, which was exceedingly abundant as already stated. Resin washes are here in considerable favor, and are said to be effective when they are boiled for a long time. In one place the



Fig. 7.
Collecting Beetles.

scale had taken a new start, and had shown an indication to become injuriously abundant. Here the trees had been sprayed with the resin wash, with the result that the insects had been reduced to harmless numbers. There was still some scale present and it was realized that it would be necessary to watch and perhaps spray again during the coming winter. It has been estimated that in Los Angeles county over one million *Rhizobius* have been liberated; either direct importations or specimens obtained from Santa Barbara. Of all that number it is possible to obtain only a few specimens here and there at this time. Everywhere the black scale is still abundant, and if not as plentiful as it has been at times in the past, I cannot see that there is any evidence to associate any present reduction in numbers with the *Rhizobiids* that have been brought in. As to the San José scale in this part of the State, I have no hesitation in saying that there is not a particle of evidence that any of the *Rhizobiids*, or of the other species introduced from Australia, had anything to do with lessening it. There is considerable evidence that the *Aphelinus* has done good work. There is no doubt that *Chilocorus bivulnerus* has done and is doing excellent service, and this matter will be again referred to. It is also certain that some other cause, which I did not succeed in positively identifying, is at work in reducing the scale in number, and this may be the fungous disease upon which Professor Woodworth lays so much stress.

On the Woodbridge ranch at Pasadena, *Rhizobius lophantæ* was found in fair numbers; the only place thus far in the State where it could be said to be anything more than a very rare insect. It is interesting that this place, where the insect is abundant, is quite badly infested with the black scale, and further, that this is one of the worst-infested orchards that I have seen, so far as the red scale, *Aspidiotus aurantii*, is concerned. Dr. Woodbridge does not pretend that the species feeds upon this red scale, and yet this belongs to the same genus with the San José scale, very much resembles it in general appearance, although a little larger in size and should, it would seem, be as attractive a food as the pernicious scale. The San José scale has never been in this orchard, which indeed contains practically only citrus trees. It is very certain that everywhere about this vicinity the San José scale occurs, and it seems rather curious that if this Coccinellid feeds on it at all readily, that it has not been "exterminated."

The condition of affairs at Berkeley is fairly well described in the extract from Professor Woodworth's report on a previous page. There is no San José scale here at the present time, but *Aspidiotus rapax*, the greedy scale, is abundant. This scale does not seem to be eaten by the Rhizobiids, although its resemblance to the pernicious scale is exceedingly close.

At San José, I found plenty of the pernicious scale scattered about in abandoned orchards, and in several cultivated orchards examples were to be found; but practically it amounts to nothing—that is to say, it is not injurious. It is not nearly so abundant at the present time as a new scale, belonging to the same genus, *Aspidiotus*, which is said to be *A. pyricola*, and a comparatively recent introduction from Italy. It is known here as the Italian pear scale, and is increasing in numbers. According to Mr. Ehrhorn, the commissioner, it has been increasing for some time, and promises to become injurious unless active measures are taken against it. I found that *Chilocorus bivulnerus* was feeding upon the species greedily, and in the larval as well as adult condition was doing good work in preventing its too rapid spread. There is also a small black Nitidulid, *Cybocephalus californicus* Lec., at work in these orchards, and this I found crawling about on a few of the old trees yet infested by San José scales. No trace of *R. lophantæ* was seen, but it is claimed that it does occur in this vicinity later in the season. The black scale is very abundant on peach trees in this vicinity, and also infests other deciduous trees. The *Rhizobius ventralis* does not seem to remain on trees of this kind, and there certainly does not appear to be much reduction, judging from the number of specimens still remaining. Here again I found the San José scale in the larval stage and a few specimens were just setting. This was on May 28th, and I am informed that the scale does not, as a rule, begin to breed much before this time. Mr. Ehrhorn has studied entomology under Professor J. H. Comstock at Cornell University, and has made, in some respects, more accurate observations than any of the other gentlemen whom I had the pleasure of meeting. He was able to give me dates based upon positive observation, and the information obtained from him made it possible for me to reach more definite conclusions concerning the method in which the scale was exterminated than I could otherwise have done. Mr. Ehrhorn found the twice-stabbed lady-bird, *Chilocorus bivulnerus*, ovipositing or laying eggs on

February 19th. This means, of course, that the adult insects had been feeding for at least a few days before. It means, also, that between the latter part of February and the beginning of May there must have been one full brood of larvæ which I found, on reaching Los Angeles, already pupating. Beetles from the larvæ were feeding in immense numbers at San José upon scale insects everywhere, and eggs laid by them were scattered all over the trees. There was also a considerable number of young larvæ of the second brood, and the important point to be considered is that from the latter part of February to the middle of May great numbers of these lady-birds were in times past feeding upon the San José scale as an almost exclusive food, during a period when the scale was not breeding. Each specimen of scale destroyed meant several hundreds of larvæ less later in the season, and it is this feeding upon the scales before they began to reproduce that has enabled the insects in California to master the pernicious scale. Furthermore, Mr. Ehrhorn has bred *Alphelinus fuscipennis* from the scales in January, and has actually found it in the field on infested trees during that month. Here again this parasite was evidently at work on the scale during a period when the scale itself was dormant and was not increasing. Every specimen destroyed, therefore, represented an immediate decrease and a great reduction of possible larvæ for the ensuing season. It is more than likely, from what I have been able to learn, that about midsummer *Rhizobius lophantæ* or some other species becomes an important aid by feeding upon the young scales and crawling larvæ; but here another factor comes in, which, however, is not based upon personal observation. It is stated, quite positively by some, that during the hot weather of midsummer the San José scale does not breed rapidly. There seems to be an interval lasting nearly a month during which few or no larvæ are seen on the trees, and the intense heat sometimes prevailing at that time during the middle of the day, it is claimed, will destroy young scales. In other words, while in California the scale is inactive during about the same period that it lies quiet in New Jersey, its enemies, predaceous and parasitic, are constantly working against it in its dormant stage, while with us it is entirely free from attack during the same time.

On the 29th, still at San José, I found a large red mite digging into the *Aspidiotus pyricola*, and feeding upon the eggs beneath it. This insect was present in sufficient numbers to be of considerable

benefit, although nowhere did it eat out all the eggs beneath any individual scale. I found none on trees infested by the San José scale, and nothing but the *Chilocorus* was there present in any effective numbers. I did succeed in finding a few specimens of *lophantæ* after close search; but they were not feeding upon the scales, and at all events were not sufficiently abundant to have the slightest effect upon the insects present at this time of the year. In a nursery near San José all the scales that had been found in this part of the State were present on the nursery stock, including the injurious species of *Aspidiotus*.

At Mountain View, the Ehrhorn ranch contained a very large number of deciduous trees in beautiful condition. It is one of the prettiest orchards in this part of California and especially well kept. Almost all varieties grown are infested by the black scale, and on plums and prunes the brown scale is abundant. It is said, however, that the trees are in much better condition than they have been in years past, and parasites are credited with this result. The scales are sufficiently bad yet, however, for all practical purposes. There are also some pear trees still infested by the pernicious scale, and many of the insects are living and healthy. In times past this scale was the one that they considered of greatest importance here, as elsewhere in this region; but now no attention is paid to it. The trees infested at the present time have been infested in much the same way for several years last past, sometimes a little worse, sometimes a little better, but never seriously enough to make active measures necessary, and there seems to be no tendency to spread within the orchard. The *Aphelinus* and the *Chilocorus* are credited with having done the effective work here; but *lophantæ* has also been present and is said to do good work during midsummer. Just now, there are few specimens present—found four of them after a little search, but none of these were feeding upon the scales. Among the black scales we found a few specimens of *ventralis* and a few larvæ. This species was introduced three years ago into this orchard, a large colony being liberated. A few are to be found every year, and they have evidently become well established. They do not increase in numbers, however, and they seem to have made no particular impression upon the scales. On these trees I again noticed the fact, already mentioned, that at least 75 per cent. of the insects beneath the pernicious scales seem to be dead. The impression here was again very strong that the species

was feeble. The larvæ, in crawling about, move slowly, as if they had no interest in life, and there was none of that bustling activity which is a feature of the species in New Jersey. The scales here seem to lack vitality, and I believe that it is this lack that is accountable for their small number, rather than the insects that feed upon them. The red spider found at San Joé was again found at Mountain View, as was also the little *Cybocephalus californicus*; the latter being, next to the *Chilocorus*, the most abundant. Noticed also several specimens of the *Aphelinus* hopping about over the scale-infested trees, and I am informed that they have been observed here in January and February.

At Marysville there are several trees within the city limits badly infested with the San Joé scale. One in particular, which was thoroughly covered, was pointed out to me by Mr. Harney. The young were just hatching here, and a few had already set, but there is no general covering of the tree by the young, although the adult females are enormous and in apparent good condition. There certainly is nothing that is keeping down the species on this tree, although I did find on it a specimen of *Rhizobius lophantæ*. Visited several orchards in Yuba City—peach, pear, apricot, prune and nectarine—and found a little scale present almost everywhere, even on a young orchard set out only two or three years ago. Nowhere, however, was there any great quantity of it, and only where it could be seen on the fruit itself was it conspicuous. Generally, pears were infested, and a few were on peaches. The other varieties of fruits seemed to be exempt. There was a great dearth of natural enemies, so far as could be seen, and this was accounted for by the fact that everywhere spraying was done. Nothing is here trusted to natural enemies, but spraying is constantly resorted to, to keep down the scale. May and June are here said to be the months during which the scale increases most rapidly, and during the hot weather reproduction seems to be very slow. The lime, sulphur and salt wash is the remedy, and the "Bean" spray-pump is the machine used. While the scale had at one time threatened the fruit industry with extinction, the growers now feel that they are able to control it by ordinary care, and they trust nothing to natural enemies.

On June 3d most of the day was spent in orchards in Sutter county, under the guidance of Mr. Harry P. Stabler, and here there is very little scale left anywhere. There is scarcely an orchard in which a

few specimens cannot be found on close search, but I did not see a single tree that could be considered badly infested. Neither did I see anywhere any considerable number of lady-birds of any kind. Everything looked neat and clean, and the trees looked in as good condition as any that I have seen in the State. I found on one tree infested by the pernicious scale, the young further advanced than I had seen them anywhere else; that is, they had passed the second molt and were probably nearly full grown. Spraying is universal here, and the lime, sulphur and salt wash, or a patented mixture called I. X. L., which is said to be its equivalent, is the material used. One of the most troublesome insects that they have to deal with here is a plant louse on the roots of pear trees, which, when it becomes abundant, results in weakening and eventually killing the tree. The insects attach themselves to the fibrous roots, generally near to the surface of the ground, and exhaust them, checking the growth of the tree in the first place, and, as the roots die, rendering it unprofitable. The agent of one of the largest fruit-shipping companies in this part of California informs me that the heaviest shipments of pears come from this Sacramento Valley district, and a large portion of them from the vicinity of Suisun. It is from this region, he believes, that the scaly pears that we see in the Eastern markets are sent.

CONCLUSIONS.

I have set forth above, first, the general route over which I journeyed, in order to make it clear what portions of California were visited by me. Second, I have given in brief and in outline the character of the testimony gathered on the subject of the scale and its natural enemies. Third, I have given a short account of my own observations.

It is obvious that I could not possibly detail at length all the evidence gathered by me. I made the acquaintance of a large number of people directly or indirectly interested in fruit culture, and talked with them under all circumstances and at all times—on trains, in hotels, on the farm and in the street—and each day I carefully noted what had been told me by the different individuals. Of course, not all the testimony was of equal value, and little of it was based upon actual or reliable observations. Nevertheless, a large number of facts was secured, and by proper questioning the true belief on certain points

was always arrived at, and everywhere it was my effort to bring out information that would explain, confirm, contradict or modify my own observations. I do not pretend for an instant that, in the brief visit I made to California, I was able to make final observations on the relation of predaceous and parasitic insects to the injurious species upon which they preyed. On the subject of the black scale and its enemies, and the soft scales generally, and the insects feeding upon them, there is no necessity for my expressing a definite opinion here, though I have said enough to indicate what I believe. It should be the task of the entomological workers in California to settle that question, and Professor Woodworth, in the report already cited, has made a step in that direction. In another part of this report, in considering the general relation of insects to each other, I will try to set out the actual facts as they appear to me.

In the matter of the San José scale, I feel that what I have seen and what I have learned are sufficient to enable me to speak positively. If the result is not as satisfactory as might have been wished, there will, at all events, be no further excuse for indecision as to measures that are to be taken. The true home of the pernicious scale, whence it was introduced into California, has not been definitely settled. There is absolutely no evidence of its introduction from any foreign country. Professor Cockerell, of the Agricultural College of New Mexico, one of our students of scale insects, says that there is nothing inconsistent with the idea that it may be a native species. If this is so, it is more than likely that its home is somewhere in the Northern Pacific States. It was suggested to me by Mr. E. A. Schwarz, of Washington, that granting this, *Crataegus* might easily have been its native food plant and *Crataegus* is very abundant in parts of Oregon, a considerable amount of it being found in the vicinity of Portland. I spent the best part of a day in searching near this vicinity, but although I found no pernicious scale, this does not prove that it does not exist elsewhere on this plant. The life history of the scale indicates that it flourishes in a region in which there is a moderately severe winter, and where permanent warm weather does not set in much before the month of May. It is likely that the best environment for it is a temperate, somewhat moist, climate, and that intense, dry heat is not in the long run favorable for its rapid reproduction. This seems to be proved by the almost universal testimony that May and June in California are the months

during which the larval scales are most abundant, that during midsummer there is little hatching, and that at this period scales seem frequently to be killed by the intense heat. Furthermore, it is claimed that in some localities into which the scale has been introduced it has been promptly killed off completely by the intense summer heats. On the other hand, it has survived, in New Jersey, temperatures from ten to sixteen degrees below zero, without any apparent impairment of its vigor. The fact that everywhere in southern California I found dead insects beneath the scales and that, even where young larvæ were moving about, they gave the impression of loss of vitality, seems to prove that in the course of years the scale deteriorates in a hot climate. It is interesting to note that the scale was least troublesome in the most southern parts of California, that it was most destructive from San José northward, and that its disappearance from natural causes was confined to points from San José southward. There is no record of any point north of San Francisco in which the scale disappeared naturally; at least none that I have been able to verify. The disappearance of the scale began earliest in the most southern range of the species, at the very points where it was last introduced, and here the climatic conditions were most disadvantageous to it. Here, also, its natural enemies were distinctly favored by climate. The twice-stabbed lady-bird, *Chilocorus bivulnerus*, begins breeding at San José and southward in February, and there is one full brood of larvæ and beetles at least before the scale begins to reproduce. Where this lady-bird is as abundant as I found it everywhere in southern California, the number of scales required to feed it is, comparatively speaking, enormous, and by the time that in May the scale begins to bear young, the second brood of larvæ and the lady-birds of the second generation still on the tree, feasting upon the young just set, must at least keep the scale within bounds if they do not so reduce it that later on it can scarcely recover. It is probable, indeed, that in some parts of California this insect breeds during the entire winter, for Mr. Cooper is quoted by Howard and Marlatt as stating that it occurs in Santa Barbara "on plants throughout December and January in great numbers in all stages." It seems in fact to be less abundant in midsummer than at any other time. The *Aphelinus fuscipennis* probably breeds throughout the entire year. It has been actually observed hopping about among the scales in January and February, and I found it quite abundant in May. Although we do

not have the entire life history of the parasite, it is probable that it requires not more than a month to undergo its changes. With these two enemies preying upon it during the months when the scale insect is quiescent, the reduction of breeding females must be enormous.

It is hardly necessary to point out that in New Jersey we cannot duplicate such conditions. Under no circumstances could we expect that, before the month of April at least, enemies of the San José scale would become active. As a matter of fact, we know positively that the adult *Chilocorus bivulnerus* does not come out of its winter quarters in New Jersey until late in April, and then only in small numbers. Long before the first larval brood comes to maturity, the scale has commenced to breed in such quantity that it is wholly beyond the control of the *Chilocorus*. The same statement applies to the other scale-feeding lady-birds occurring with us, and to the *Aphelinus*. I am inclined to attribute to the *Chilocorus* and to the *Aphelinus* a large responsibility for the destruction of the San José scale in southern California, but they were favored in their campaign by the climatic conditions just detailed, which it is simply impossible to reproduce in New Jersey, and by diseases the nature of which we do not yet know. Even in northern California the same insects were not able to accomplish the same end, though the climatic differences are much smaller than they are between California and New Jersey.

As to the part which the *Rhizobii* played, there are only two species which it is claimed feed upon this scale; that is, *R. debilis* and *R. lophantæ*. *Rhizobius debilis* seems to have multiplied nowhere except in Santa Barbara county. I found no specimens that had been collected anywhere outside of that locality, and saw none even there myself. There is a good deal of talk about *debilis* everywhere, but all the supposed specimens that I saw were *lophantæ* or *Scymnus marginicollis*. At Pasadena, *debilis* was talked of altogether; but everything seen by me was *lophantæ*, and there is not a scintilla of evidence that anything but *lophantæ* occurs there. *Lophantæ* was introduced many years ago; no one knows how. It has made itself at home everywhere from San Francisco southward, and occurs north at least to Marysville as well. It is, however, more common in the cañons and along streams than it is in cultivated orchards, and it certainly does not begin to breed, even in California, until late in May or the beginning of June. This is true even at Santa Barbara, the most

favored locality in this favored State, and we could not expect in New Jersey, even if the species was introduced here and made to do well, that it would come out of its winter quarters before the beginning of June, when thousands of young scales are already on infested trees. It is universally stated in California that *lophantæ* is most abundant during midsummer and in hot weather, and is therefore most effective against the scale at the period when the scale in California is least active. In New Jersey, the activity of the scale is as great in midsummer as at any other period, and *lophantæ* under the best circumstances could not keep pace with the scale. In New Jersey, the San José scale continues to breed until the latter part of October, and in a mild season until well along in November, if not to the beginning of December. All our Coccinellids go into winter quarters in September,* and it is rare to find even *Chilocorus* in that month. The scale, therefore, has a period of at least thirty days to breed, with practically no natural enemies feeding upon it. We have no evidence as to how long *lophantæ* breeds in California. It is scarcely to be expected that an insect which appears there so late in the season and is most active during the hot period would breed here later than our native species. It is seen, therefore, that while climatic factors favor natural enemies and work against the scale in California, the exact opposite is true with us. To restate the case: In California south of San Francisco, *Chilocorus bivulnerus* and *Aphelinus fuscipennis* feed upon the scale for from six to eight weeks before the scale itself begins to reproduce, and in some places during its entire dormant period. During the period of greatest heat in California the scale is less active and reproduces slowly, while during that very time *R. lophantæ* is most active, most abundant and again has an advantage over the scale due to the climate. We cannot, in New Jersey, duplicate these natural conditions. We have with us, naturally, the most effective enemies of the scale in California, that is, *Chilocorus bivulnerus* and *Aphelinus fuscipennis*. We do not have, naturally, the *Rhizobius*, and even if the introduction proves entirely successful and the insect makes itself at home and breeds with us, we cannot expect of it the same work that it does in California, because it does not get as early a start and because it does not have in its favor the decreased activity of the scale during the same periods. Furthermore, the scale has an advantage with us in breeding a month longer than any of the natural enemies that feed

* *Smilia misella* has since been found active in December.

upon it here. There is one other point that is worthy of consideration. Even in California, the natural enemies of the scale did not get it under control until, in most cases, the orchards were practically abandoned and were allowed to become overgrown with weeds and grasses. This condition of affairs favored the survival of the beetles. Clean cultivation and a lack of rubbish and dead wood everywhere are distinctly unfavorable to the survival of lady-birds and many other species of insects as well. They are always most abundant where there is the greatest amount of rubbish, among which they can seek shelter. When infested orchards were allowed to grow up and to take care of themselves, lady-birds found it more easy to obtain cover, and to survive, and they increased much more rapidly than would have been possible under other circumstances. Even at the present time the worst-kept orchards always show the greatest number of lady-birds present. This was universally seen near the cities and towns, where neglected orchards were found in the greatest number, the lands having been divided into town lots awaiting sale. Here the lady-birds were always in greatest abundance. In the best-kept orchards, except olive, where cultivation was clean, and where the trees were carefully tended, the smallest number of lady-birds were found. The surroundings simply did not suit them, and they failed in finding the necessary shelter for their quiescent period. If, in the mild winters of California shelter is essential to the greatest abundance of lady-birds, how much more would that be the case in New Jersey! In our well-cultivated orchards, in which it is necessary to keep things clean to reduce injurious insects in general, there would be very little chance for large quantities of lady-birds to live through the winter. It is a matter of interest that on the Cooper ranch, the one place where *Rhizobius* did best, olive orchards predominate. The olive foliage offers peculiar advantage in the way of shelter to insects, and I was told that in the folded leaves *Rhizobiids* could be found dormant at almost all periods of the winter. In deciduous orchards, where the trees are entirely bare during the winter, no such shelter is available, and this, perhaps, explains why in the orchards of northern California, lady-birds have been of no particular benefit. In view of all the facts that have been set forth, it is my firm conviction that even if the species introduced from California into this State should do just as well as they have done in that State at large, our orchardists would not be justified

in relying upon them to lessen or even keep within present limits the San José scale. In southern California, natural enemies, aided by climate, sufficed to keep the scale in check, and in some places to almost exterminate it. The same insects, without the climatic aid, cannot in the least check the scale, for the two effective species, *Chilocorus bivulnerus* and *Aphelinus fuscipennis*, are natives of our State and fully adapted to our climate. This is not theory, but observable fact, which every grower can verify. The addition of the one other species which in California is said, but not proven, to feed upon the scale, may to a small extent lessen the numbers of the pernicious scale, but it cannot, even under the most advantageous conditions, control or lessen its reproductive powers. Any dependence upon natural enemies in New Jersey will, in my opinion, result in disaster. Our conditions here approximate much more nearly those of northern California than those of southern California. If we are to pattern ourselves by what has been done elsewhere, we must pattern ourselves after this region, in which the conditions are most nearly like our own. There can be no valid pretense that north of San Francisco the San José scale has been controlled by natural enemies. There is every evidence, on the other hand, that it has been controlled by the expenditure of a great deal of money and by much hard labor. The scale is yet a threat in California that is heeded everywhere by the careful fruit-grower. It is not feared as it has been, because it has been proved that it can be controlled by proper measures, but of the great number of farmers with whom I talked in Yuba and Sutter counties, there is not a single one who pretends to rely upon anything but his own efforts to keep the scale in check.

Finally, before closing this account of my Californian trip, it is my pleasant duty to express my sincere gratitude for the uniform courtesy extended to me by all the persons mentioned in this report and by the farmers and fruit-growers whose places I visited. To Mr. Craw, especial thanks are due for his lively interest in my mission, and for the facilities and introductions with which he supplied me. His work in California is an extremely important one, and there is no doubt it will be well done so long as it is intrusted to him.

THE RELATION OF INJURIOUS INSECTS TO THEIR ENEMIES.

Before recording what has been done to introduce predaceous insects into New Jersey, it is well to consider somewhat the general relations of such species to their prey.

It is a fascinating theory that we may be able to array the forces of nature against each other; that for all injurious insects we may secure, somewhere in this wide world, a species to prey upon it, and that if we can only get a sufficient number of parasites and predatory species, we may be able to dispense with spraying and with other methods that are expensive and laborious. Besides insect enemies there are diseases, fungous and bacterial, that attack injurious insects, and by cultivating these and simply planting the germs in a favorable locality in cases of a destructive visitation, we may let them attack the destroying hordes, that we may secure exemption without further trouble. The idea is a very pretty one, but it fails to take into account the workings of nature herself. Nature, as such, has no love for the farmer. On the contrary, she is his bitterest enemy, because she interrupts her course of action. He compels the ground to grow just what he chooses it shall grow; he robs it of superfluous moisture in one place, and he adds water where nature never provided for it. The effort on the part of the farmer to grow crops is a fight to compel nature to do what, under ordinary circumstances, she never would do. The result is that natural forces are all arrayed against the farmer, and as a consequence of his interference he is compelled to battle with weeds and with injurious insects of all kinds. The present distribution of insects on the surface of the globe is the result of ages of growth and adaptation. It is the final adjustment of species to each other, arrived at by innumerable small modifications, which have taken place in the past, and have rendered each species fit to survive under the conditions in which it is placed. In the balance thus established, all species bear a definite relation to each other and to the plants upon which they feed. It sometimes happens that the plant-feeder obtains a little the advantage from some cause; but it is temporary only, and in a short time its enemies resume control and sometimes even reduce it to almost the point of extinction. Examples of this

we see in the occasional outbreaks and following disappearance of the "army worm."

But nature never works for the *extinction* of any but useless creatures, and under ordinary circumstances we cannot force her to do violence to her laws. All the species inhabiting a country are adapted to its climate and, everything else equal, can live only in the climate to which they are especially adapted. There are, however, exceptions to this, and we sometimes find species with unusual powers of adaptation that are able to sustain themselves under conditions apparently adverse and very different from those under which they first originated. Similar climatic conditions prevail over great portions of the surface of the earth; but continents and islands, and even parts of the same continent, may be separated from each other by barriers insurmountable to insect life. Thus a range of mountains or a desert may separate two faunal regions, the insects of one side being quite different from those on the other, though the climate may be approximately the same. Parts of Europe have much the same general climate as parts of the United States; but the insect fauna is, with few exceptions, different as to species. It is not unusual, though by no means common, for an insect belonging to one country to sustain itself in another in which the climate is similar or more favorable. It is rarely that one is able to sustain itself in a climate more unfavorable than the one in which it originated. Plant-feeders as a whole show greater powers of adaptation than predaceous species.

The balance established by nature is disturbed by man whenever he cuts down forests, or plants the desert, and substitutes for the vegetation natural to the soil, crops intended for his own benefit. When he clears a piece of land and cultivates it, plants an orchard and keeps the ground constantly stirred and in the best possible condition for growing the desired fruits, he offers an advantage to the species which thrive upon his fruit trees, by supplying them with an abundance of food for which they are not compelled to search, and he creates a disadvantage for the species which normally prey upon the fruit-feeders, because he disturbs the hiding-places in which they naturally lurk. The result is, that he has changed normal conditions to his disadvantage, and in order to restore them he must, by efforts of his own, replace those forces which nature no longer puts at his service. The parasites are not so much affected by man's efforts as are the predaceous species; but there never was a case yet where parasites destroyed their hosts en-

tirely, because the destruction of the host would carry with it, necessarily, the destruction of the parasite as well, and, under ordinary conditions, as nature has arranged them, both parasite and host flourish—the latter of course at the expense of the farmer. The codling moth, with its numerous parasites, is a very good example of this. It goes without saying that predatory insects themselves have natural enemies, and that they are kept in check by parasites and other creatures that feed upon them; hence, in the long run, there is no advantage on either side, and we have very much the same percentage present each year. This is well illustrated in the cut-worms, of which, in New Jersey, at least 75 per cent. are parasitized each year, yet which usually re-appear in equally destructive numbers the season following.

In the course of the development of the fruit industry, plants have been imported into the United States from all parts of the world, and many of these when they reach us are infested by insects peculiar to them. They may be brought in on the fruit stock itself, or in the soil among the roots, among the moss in which the plants are packed, or even in the box or crate containing the stock. The great majority of insects introduced in this way die. They may sustain themselves for a season, in some instances; but in most cases they do not live even so long, and disappear before they are noticed. Occasionally, however, we get a hardy species that succeeds in breeding and whose progeny adapts itself to the new surroundings. Now, here, we usually have a dangerous form, because the chances are that, where only a few specimens are introduced, the parasites or other natural enemies are not brought in with them; or the parasites may not be able to sustain life where the original species flourishes. The result is that, once established, it becomes a difficult one to deal with, because nowhere in this new home has nature provided any save climatic checks for it. The circumstances, in fact, may be even more favorable than they were in its original habitat, because climatic conditions may be better; hence an insect innoxious in its own country may become injurious with us, as for example the elm-leaf beetle and the gypsy moth, though these sometimes become pestiferous in their native homes.

If an insect, harmless or rare in its own home, becomes injurious here, there is a chance that, by studying its natural enemies in the country of its origin, we may secure species that will keep it in check with us also. Such a case occurred in California when the fluted scale, *Icerya purchasi*, became destructive and was reduced to harm-

less numbers by introducing its natural enemy, the *Vedalia cardinalis*. Here we have one class of cases that stand by themselves and cannot be used as an argument for or against any other. It is, of course, quite possible that similar cases, admitting of the same treatment, will again occur, and we may then hope to repeat the same success.

It has taken ages to develop and fix the present food habits of predaceous and parasitic species, and under ordinary circumstances they would rather starve than attempt to feed upon an insect unfamiliar to them. Sometimes the food is a single species only, sometimes the species of a genus, sometimes the members of an entire family, but almost always some limit exists to the range of food species.

Sometimes an herbivorous species is almost or entirely free from predaceous or parasitic enemies in its natural home, owing to the scarcity of its food-plant, or for some other natural reason, and such a one, if introduced into a new locality where it flourishes, usually remains exempt from attack. So the Colorado potato beetle, free in its own home, is not attacked to any extent by our numerous predatory forms, and no parasites of allied forms infest it. There is an excellent opportunity here for some parasitic or predaceous species to obtain an abundant food-supply, but it illustrates the extreme conservatism of nature that it has not yet been seized. An insect of this character may be normally considered beyond the reach of natural checks, except such as the farmer does not approve of.

For instance, starvation is one of nature's most serviceable checks. If an insect becomes too abundant for its food-plant, it perishes of want, and the San José scale in New Jersey would, no doubt, practically exterminate itself in a few years, if let alone, by killing all the trees infested by it; but it is to be doubted if many of our growers would not consider the remedy as a little worse than the disease.

An insect injurious in its own home will almost certainly prove injurious in a country into which it is introduced and flourishes, and we cannot hope to introduce better natural conditions against it there.

Thus the black scale, *Lecanium oleæ*, is a pest in its native country, where Rhizobiids are also native, and it is a vain hope that the latter will accomplish more in California than they do where they originated.

On this point it may be interesting to quote from the report of Mr. Chas. P. Lounsbury, Government Entomologist at the Cape of Good Hope, for the year 1895:

"All four of the species of lady-birds (*Orcus chalybeus*, *Orcus australasiae*, *Rhizobius ventralis* and *Leis conformis*), at which attempts at colonization have been made in this country, were introduced into California early in the year 1892, and subsequently other and larger colonies were brought from Australia to reinforce the first. Four seasons have now elapsed since the first were imported, but as yet the success of the beetles in the work for which they were introduced has not been marked. Of the four, *Rhizobius ventralis* has attracted the most attention. It was especially intended to destroy the black scale (*Lecanium oleæ*), which is exceedingly common and injurious in many parts of the State. In a few groves the scale is said to have been almost exterminated, but in most localities the lady-bird has proved a failure, and in southern California, the horticultural papers have advised the fruit-growers to return to spraying and fumigation to clean their trees.

"*Rhizobius ventralis* multiplies with much greater rapidity than any of the other three. Mr. Koebele, who was instrumental in introducing it into California, estimated that there were six broods a year, and that under favorable circumstances a single female would in this time be the progenitor of 15,000,000,000 insects. With such prolificacy, it was confidently expected that the beetle would multiply sufficiently in two years to rid the country of the black scale, as *Vedalia cardinalis* in a similar period has done with the Australian bug. But even at the end of four years these expectations remain unfulfilled."

Concerning the success of the *Vedalia* in exterminating the fluted scale, he says:

"Such a striking case of the value of an imported enemy of a destructive insect is entirely exceptional, and it is one which will be seldom or never repeated. A combination of such favoring conditions may never again present itself. Few comparisons can be drawn with the conditions surrounding any of the other lady-birds we are striving to colonize."

Mr. Koebele, who was the agent for introducing the Rhizobiids into California, is an enthusiast on this subject and, like all enthusiasts, given to predicting. He has predicted all sorts of things in his publications and many more in his reported talks, and up to the present time not one of them has eventuated! On the other hand, time has contradicted almost every one of the assertions so confidently put forth, and it illustrates the danger of relying upon superficial observation for predictions which a scientific student with even a rudimentary knowledge of nature's methods would know could not be fulfilled.

Mr. Koebele is a good collector, an earnest worker and, as already stated, an enthusiast, but he is one-sided in his views of facts, and he allows nature's magnificent possibilities to confuse him into considering them as probabilities. For instance, the black scale multiplies one thousand-fold each year, or, in other words, each adult lays about 1,000 eggs; the descendants of a single pair of *Rhizobius ventralis* may number in one year fifteen thousand millions!!!—*ergo*, the lady-bird *must* clear out the scale if given half a chance. It is a cold fact that the black scale yet flourishes, even in Santa Barbara county, while in all other parts of California it is at least as abundant as ever. In orchards where thousands of *Rhizobius ventralis* were introduced one year, only hundreds were found the year after, and exactly as much scale as before.

Mr. Koebele also said in his report on "Predaceous Insects," in 1892, "some 1,500 different beneficial lady-birds are known at present in the world, and more than half of these will feed upon scale insects." Had Mr. Koebele been just a little more familiar with our actual knowledge of the food habits of the Coccinellidæ he would probably never have made any such statement. As a matter of fact, the food habits of more than half the described species are in whole or in part unknown, and of those of which we do know them, a very small percentage only—among them some of our rarest species—are confined to scale insects. Furthermore, Professor Woodworth claims, with much show of reason, that even *R. ventralis* eats, preferably, those specimens of black and soft scales that are diseased, and I am strongly inclined to believe, from my own observation, that the insect is sometimes as fond of the smut fungus growing on the "honey dew," produced by the black scale, as it is of the scale itself.

Mr. Koebele says elsewhere, in his "Studies of Parasitic and Predaceous Insects in New Zealand," etc., * * * "it must seem plain to every thinking individual that a few dozen of such species—and the world possesses hundreds of them—naturally *must* in time keep in check the scales destructive to fruit and other trees, so as to effectually prevent injury. *We can solve this simple matter* * *by introducing all the insects preying upon Coccids* as well as upon other injurious insects and protecting the same by discontinuing the process of spraying and fumigating." This statement is an absurdity upon its face; but let us test it upon what has actually occurred in Cali-

* The italics are mine.

fornia. Mr. Koebele claims to have sent in some 40,000 specimens in from 40 to 60 species, most of them listed by him under the title of "Insects Feeding upon Coccids." Omitting *Vedalia cardinalis* and *Novius koebelei* feeding upon *Icerya*, which stand by themselves, about half a dozen species out of from 40 to 60 gained a footing worthy of attention in California: *Orcus australasia*, *O. chalybeus*, *Rhizobius ventralis*, *R. debilis*, *Cryptolæmus montrouzeri*, and perhaps *Leis conformis*. To these may be added *Rhizobius lophantæ*, also described as *R. towombæ*, which gained a foothold by an accidental introduction many years ago. Of these, *Orcus australasia* has died out altogether. *Orcus chalybeus* barely sustains itself in a single restricted locality in Los Angeles county. *Leis conformis* seems to have died out, or at least has not increased. *Rhizobius ventralis* has firmly established itself in Santa Barbara and Ventura counties, and occurs annually in goodly numbers, but it seems unable to thrive elsewhere as yet. There is some evidence, however, that near the coast, in Los Angeles county, it will eventually make itself at home. *R. debilis*, of which Mr. Koebele says, "next to *R. ventralis* Er., the most numerous of all the Rhizobiids, and will prove one of the best acquisitions we could get," is so rare in 1896 that I have not been able to get hold of a single specimen. In the very orchards where it was said to occur in extravagant numbers, not a specimen could be found, and not one of the colonies introduced into New Jersey, which it was intended should consist of this species chiefly, contained even a single specimen. *R. lophantæ* was accidentally introduced many years ago, and is well spread all over southern and central California. It is rarely abundant, however, and prefers woods and cañons to orchards. It is not a factor of any importance as against scale insects. Concerning the *Cryptolæmus*, I can say little. It seems to do well in confinement, but I have not seen anything of it in the open. At Berkeley, where some specimens were colonized on plants infested by mealy bugs, the beetles are said to have died out, while it is certain the mealy bug has not.

The whole practical effect, then, of Mr. Koebele's scouring "New Zealand, Australia and adjacent islands," has been the introduction into California of a single species, which, after four years, has established itself in two counties, in which black scales are yet abundant. I will go further and say that there is no reliable scientific evidence that any reduction of black scale, even in these counties, is not due

to causes other than the *Rhizobius*. It is certain that the possible fifteen thousand million (15,000,000,000) descendants of a single pair of *R. ventralis* have not, even on Mr. Cooper's ranch, exterminated the possible one thousand (1,000) descendants of a single black scale.*

Mr. Koebele's statements as to the possibilities for predaceous species, are made without regard to the fact that such things as natural limitations exist; that geologic conditions may prove a bar for predaceous species which would not check the form they normally feed upon, and that this "simple matter" which he solves so easily, really demands a modification of nature's laws to suit the farmer. Our past attempts in this direction have not given us much hope for the future.

There remains the possibility of a "fluke." It is not inconceivable that a predatory species or a parasite, introduced without its enemies from a country in which natural conditions are against it, into a new country in which the conditions are more favorable, may increase abundantly and flourish on some native or introduced injurious species. In such a case the injurious form might be very much reduced and rendered harmless; but the predaceous species would have to become correspondingly scarce or put on new food habits, and this would give its original prey a chance to recover. A good "fluke" is equal to a success, and in the hope that some such fortunate occurrence may result, it will be my effort to introduce into New Jersey as many Coccid-feeding lady-birds from all sources as offer any possibility of surviving in our climate.

DISEASE CHECKS.

A better hope offers in another direction. While nature does not favor the farmer, and does not allow one of her productions to work out the absolute destruction of any other, she does not, on the other hand, favor the too rapid increase of any form, and disease is brought in to check one inclined to break bounds. Placed in favorable climatic conditions, the San José scale for some years bred and multiplied exceedingly. Signs are not wanting now that this exceeding prosperity may result in decreased vitality. It is certain that in Cali-

*I am using Professor Woodworth's figures here. The black scale often contains two or even three thousand eggs, but Professor Woodworth considers one thousand a fair average under ordinary conditions. In any case there is only one annual brood.

ifornia many of the insects die without reproducing. It is certain also that the young are not so numerous, and the larvæ are not nearly so active as they are in New Jersey, which became more lately infested. In California almost every infested twig shows diseased scales, but the fungus bred from them may not have been the original cause of death.

Professor Rolfs informs me that disease has attacked the scale in Florida, and Dr. Howard gives it as Mr. Marlatt's observation in Maryland, that the larvæ seem to show a lack of vitality similar to that observed by me in California. In New Jersey nothing of the kind has been observed as yet, but this feature of the case will not be left out of consideration in future experiments.

NATURAL ENEMIES OF THE SAN JOSÉ SCALE.

According to Howard and Marlatt, three, and possibly four, species of parasites have been bred from the San José scale. These are *Aphelinus fuscipennis* How., *A. mytilaspidis* Le Baron, *Aspidiotiphagus citrinus* Craw, and *Anaphes gracilis* How. All of these are also feeders on other scale insects, and as to the latter it is possible that it may not have been bred from the San José scale, but from an overlooked specimen of the common oyster-shell bark louse. *Aspidiotiphagus citrinus*, first described from California, has been bred in the East only in Florida. *Aphelinus fuscipennis* in the East first bred by me in New Jersey, has since been found infesting the scale in Virginia, and is a common enemy to it in California. It is by all odds the most abundant of the species, and the work done by the others is very subordinate. While every specimen feeding on it in ever so slight a degree aids in the control of the scale, yet in themselves these species are not of great importance.

APHELINUS FUSCIPENNIS Howard.

This little insect belongs to the family *Chalcididae*, and is a common parasite of armored scales. It occurs all over the country in greater or less abundance, and is as much a native of the Atlantic as it is of the Pacific Coast. It is very minute, hardly as long as an ordinary

San José scale is in diameter, and is of a somewhat straw-yellow color. The eyes are dark, and as they contrast in color, appear rather prominent. The antennæ, or feelers, are rather short, a little thickened at the tip, and are kept in constant motion while the insect is moving among the scales. The wings are ordinarily laid flat upon the back, and when the little creature is seen on an infested tree, it will be found walking or hopping, rather than flying over the scales, and testing them with its antennæ, seeking a suitable one in which to lay an egg. In California it is easy to find specimens on any infested tree at any time during the year. In New Jersey they are much more rare, and in many places the trees do not show the slightest signs of the presence of the parasite. A single egg is laid in each scale, and the parasitic larva feeds upon the insect underneath, checking reproduction and ultimately destroying it. When ready to emerge, the parasite cuts a small, round hole in the scale, through which it makes its exit into the open air. It is easy, therefore, to determine the part that has been played by this insect in lessening the number of scales, and there is no sort of doubt that in California it is extremely effective, particularly in the southern portions of the State. There it breeds during the entire year, specimens having been found in January and February, as well as during all the summer months. This gives it opportunities that are lacking in New Jersey, for from December until April the insect hibernates in our State, and a large proportion of the specimens are winter-killed. The species therefore begins its work on the scales in spring in small numbers only, and its rate of reproduction does not begin to compare with that of the scale; hence by the time the parasite has increased so that it might become beneficial, winter again sets in, and the spring following the same story is repeated. This is a marked example of the effectiveness of a parasite in one locality and of its absolute inefficiency in another.

The figure herewith given illustrates a closely allied species belonging to the same genus, and will serve to give a fair idea of the general habits of the scale parasites. It is probable that eventually all the parasites of the oyster-shell bark-louse and of the scurfy scale in our State will also attack the San José scale; but our species are used to dealing with forms having only one or, at most, two broods in the course of the year, while the pernicious form breeds continuously for months, and is therefore in a position to outrun enemies that control our ordinary species with little difficulty. The following is quoted.

from Howard and Marlatt as to the work of this species in California: "*Aphelinus fuscipennis* is undoubtedly a very efficient aid in keeping the San José scale in check. Mr. Alexander Craw, in the Report of the State Board of Horticulture of California for 1891, states that he found it doing such effective work in an orchard in the neighborhood of Los Angeles that complete extermination of the scale was confidently looked for. It was afterwards learned, however, that the orchard became re-infested, and also that the partial exter-

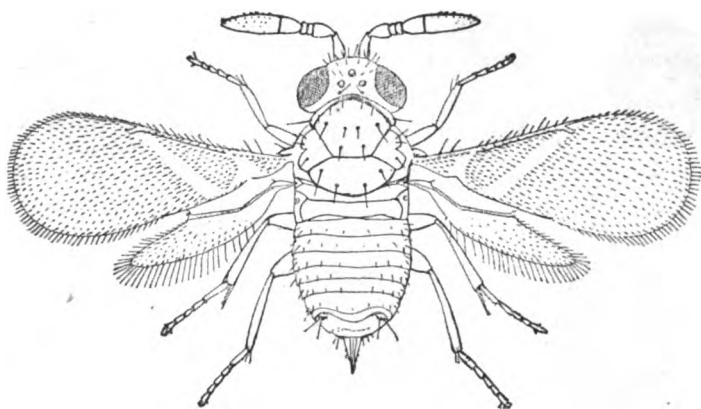


Fig. 8.

Aphelinus diaspidis Howard. (From Division of Entomology, U. S. Dep't Agriculture.)

mination of the scale in this instance was, in a measure, seemingly due to a fungous disease." This illustrates the fact that even in California reliance upon this species alone is ill-placed.

LADY-BIRDS.

The most effective enemies of scale insects and plant lice are to be found among the lady-birds or *Coccinellidæ*. These are comparatively small; sometimes even very small, beetles varying from an almost round to an oval outline, always somewhat flattened beneath and distinctly or very strongly convex above. Taken as a whole, lady-birds are predaceous insects; there are, however, some exceptions, and a few species feed upon plant tissue exclusively. Quite a number of others vary their diet by feeding upon pollen, sometimes in considerable numbers, and many of them have been observed feeding upon fungi.

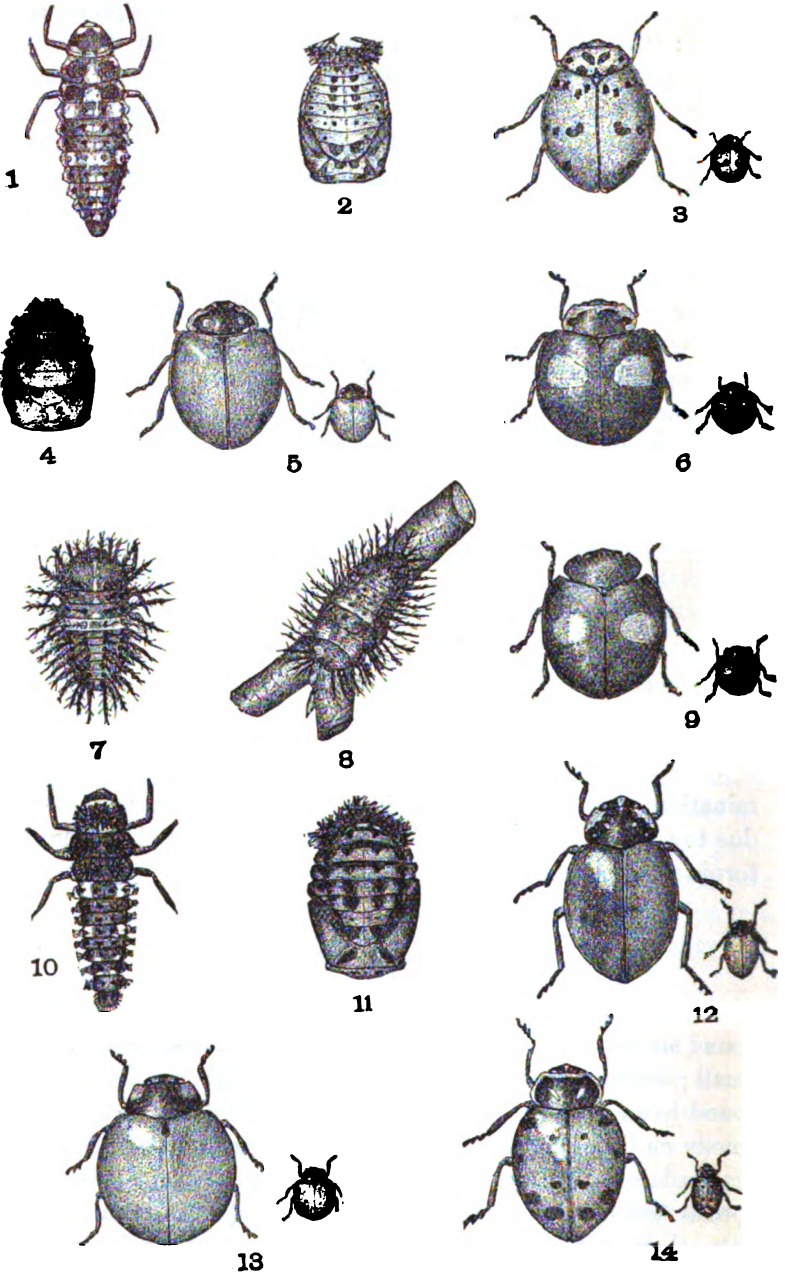


Fig. 9.

Some of the more common Western lady-birds: 1, 2, 3, larva, pupa and adult of *Cycloneda abdominalis*; 4, 5, pupa and adult of *Cycloneda sanguinea*; 6, *Cycloneda oculata*; 7, 8, 9, larva, pupa and adult of *Chilocorus cacti*, closely resembling *C. birulnerus* in all stages; 10, 11, 12, larva, pupa and adult of *Hippodamia ambigua*; 13, *Coccinella 5-notata*, var. *californica*; 14, *Hippodamia convergens*. Small beetle figures indicate natural size. (From Division of Entomology, United States Department of Agriculture.)

Occasionally a species that is normally a feeder upon plant lice may, when its food becomes scarce, attack vegetation, and under such circumstances some species have been found eating into the kernels of corn. Of the forms that are predatory, by far the great majority feed upon plant lice. A considerable number will feed upon scale insects, if no other animal food is to be had, but there is only a small proportion, in our country at least, that feed exclusively upon scale insects.

The most common, as well as the most effective scale-feeder in the United States, is

CHILOCORUS BIVULNERUS Muls.

(The twice-stabbed Lady-bird.)

This insect occurs from the Atlantic to the Pacific Coast, and from Massachusetts or even further north, to Florida; becoming much more abundant in the southern parts of the country. It is black in color, shining, almost hemispherical in shape, and on each wing cover, a little before the middle there is quite a large, dull, orange or blood-red spot; from which the insect derives its common name, "twice-stabbed." In size it varies from an eighth to three-sixteenths of an inch in length, and as increased length is also accompanied by increased breadth and thickness, the largest specimen seems more than double the size of the smallest. In California these insects may be found active at all seasons of the year, and they feed upon armored scales in preference; on the Pacific Coast generally preferring the pernicious scale to almost anything else. In New Jersey this same insect, which is also a native here, makes its appearance late in April or early in May, and nothing more is seen of it after the middle of September. Although I have made no direct observations, yet from the dates of the specimens that I have seen, and from the times that I collected them, two broods of this insect seem to be normal. The beetle hibernates and appears towards the beginning of May. It lays eggs, from which larvæ hatch about the tenth of that month or a little later, and sometime in July a second brood of beetles makes its appearance from these larvæ. In August the second brood of larvæ has been observed, and beetles apparently just issued, were found in September. It is possible, however, that in the southern part of the State there may be three annual generations. In California the number of broods has not been definitely observed; but judging from what I saw myself, there must be at least six. Such enormous

numbers of specimens as were found everywhere in California, I never saw in New Jersey, and evidently our climate is a serious check upon the increase of this species. As the scale breeds with us quite as rapidly as it does in California, it is obvious that this lady-bird can never be as effective here as it is in the more favored State. The eggs are bright yellow in color, and quite large in proportion to the size of the beetle. They are elongate-oval in shape, set on end in little groups, something like those of the potato beetle, and in a general way resembling the eggs of other lady-birds, which are not uncommonly found on leaves infested by plant lice. The larvæ are very dark gray or blackish, spiny, and with a more or less well-marked whitish or yellowish transverse band across the middle of the body. This mark is quite characteristic and makes it possible to recognize the insect in this stage with great certainty. The larvæ feed preferably upon active young or recently-set scales, and where they are at all numerous undoubtedly destroy a great number. When full grown, the beetle larva attaches itself to the bark by the anal extremity, suspends itself head down, the skin splits, and the pupa wriggles partially out of it. In this condition it remains for a few days, until ready to transform to an adult. This beetle I believe to be the most effective enemy of the San José scale in California. Combined with the *Aphelinus*, it has done most effective work in the southern counties, and is, I believe, largely responsible for the decrease of the scale in that part of the country. Though the species is also native with us, yet I imported several colonies of the Californian form in the hope that the breeding habits acquired in that State might lead to a more rapid development in New Jersey, and might give us at least one or perhaps two more broods in the course of the season. Whether this will prove possible or not, is a question.

EXOCHOMUS PILATI Muls.

(The Pilate Lady-bird.)

This insect resembles the twice-stabbed lady-bird in general appearance and markings, but is larger, attaining a length of one-quarter of an inch, and the red spot on the elytra covers a much greater space, actually and proportionately. It is also set farther forward, and in some cases touches the base of the wing covers. Instead of having a tendency to be circular or round, it is nearly always more or less

oblong or square. The most obvious distinction, however, is in the size. This insect has been observed feeding upon the San José scale in California, of which State it is a native. It is much less abundant, however, than the *Chilocorus*, and breeds very much more slowly. It does not make its appearance until well along in May or June, and seems to have not more than two, or at most three, broods in the course of the season. In fact, it acts in California much as the twice-stabbed does in New Jersey, though it becomes more abundant there than our species does with us. Some colonies of this insect were also introduced into our State, and the specimens, when liberated upon a scale-infested tree, seemed to make themselves at home. An examination made in early fall, however, failed to detect any trace of them in any stage.

ORCUS CHALYBEUS Boisd.

(The blue Lady-bird.)

The insect is of a bright blue color, without markings of any kind, and is therefore easily recognized. It has the general shape of the twice-stabbed lady-bird, and is about the size of the smaller specimens. It is a member of the same general group to which the *Chilocorus* belongs, and has much the same habits. It was introduced into California in 1892, and for a time gave promise of increase, spreading from the orchard in which it had originally been placed to several others in the neighborhood. Great stories were beginning to circulate concerning its efficiency on armored scales, but, unfortunately, instead of continuing to increase, it rather decreased in numbers, and at the time of my visit in California, was sparsely present only in the orchard into which it had been originally introduced. It was hoped that it would increase later in the season, but apparently it did not, and nothing could be found of it during the latter part of July, when an attempt was made to collect colonies for me.

RHIZOBIIIDS.

The species belonging to this general series are all small, few of them as much as one-sixteenth of an inch in length and most of them much less. They are very convex, but a little oval in outline, and are black or a little bronzed in color. The surface is more or less covered with fine silky hair, among which are interspersed longer,

bristle-like processes, irregularly set on the surface. Taken as a whole, the home of these species is in the southern hemisphere, although some species are found north of the equator. More are found, however, in Australia and adjacent countries than elsewhere, and this region is the source of the forms that were introduced into California. Two species may be found there at the present time, of which the larger is

RHIZOBIUS VENTRALIS Erichson.

(The black Lady-bird.)

This is called *ventralis* from the fact that the under side of the body is largely red in color, in strong contrast to the uniformly black upper side. The insect is said to be a general scale-feeder; but practically it seems to be confined to soft scales in California. Its favorite food appears to be the black scale, which it attacks in all its stages and to which it is undoubtedly a formidable enemy. The exact history of the species in California has not yet been worked out; that is to say, there is no definite information concerning the number of broods or the amount of food and its kind that will be taken by a beetle or its larva in the course of its life. It is asserted by Professor Woodworth that the insect feeds by preference upon scales that are attacked by fungous disease, and, if this proves to be the case, its effectiveness is limited, since the insects eaten by it would have been killed at any rate. There is no pretense that this insect has been recognized as an effective enemy of the San José scale, and it was never found by me on infested trees. The species does not occur at all in many localities where the scale has been cleared out, and in fact the pernicious scale had been practically disposed of before *Rhizobius ventralis* was introduced into California. No particular effort was made, therefore, to introduce this species into New Jersey; nevertheless, quite a number of specimens were brought in with the other material, and these were liberated in the same way, most of them in the Riverton orchard of Mr. Edward Lippincott. Some colonies were also sent to Washington, D. C., to Dr. L. O. Howard, and these were freed in the orange-houses of the United States Department of Agriculture. In August, on the occasion of a brief visit to Washington, Dr. Howard and myself carefully examined the trees infested by the black scale where the lady-birds had been liberated; but no trace of them was found and no signs of any feeding upon the black scale.

The second species is

RHIZOBIUS LOPHANTÆ Blaisd.

(The brown-necked Lady-bird)

This insect is much smaller than *R. ventralis*, some of the specimens not exceeding one-sixteenth of an inch in length and none of them becoming quite one-eighth of an inch in the examples before me. The insect has a much more shiny appearance and a distinct bronze luster, perhaps caused by the dense clothing of short brown hair with which it is covered. The thorax, or neck, is of a dull-brown color, which gives the insect its common name of "brown-necked lady-bird." The native home of this insect is also Australia and the adjacent countries, and the date of its introduction into California is uncertain. It was sent in by Koebele, it is claimed, on the occasion of his first visit to Australia, when the *Vedalia* also was introduced, but from the facts that less than two years thereafter it was already found in considerable numbers as far south as San Diego, and also in the San Gabriel Mountain cañons north of Pomona, it is certain that the species must have been in the country for a considerable number of years before that time. It is by no means as rapid a breeder as *ventralis*, though it is much more active, and seems to have no preference for cultivated orchards, occurring quite as abundantly in the wild lands as anywhere else. This species is unquestionably a scale-feeder in all its stages, and there is no doubt that it feeds upon the San José scale; yet from what I saw myself and from what I could learn from others, it was never abundant enough on infested trees to have been a factor in reducing this scale. Up to the beginning of June it was impossible to find larvæ, and only a few specimens of the beetle could be obtained here and there. At best, the insect seemed to be a comparatively rare one in most localities. This was indicated by the fact that, except for a few in the first sending, none were received from Santa Barbara, and they never became plentiful enough in the San José district at any time during the summer to enable the commissioner to gather colonies to send into New Jersey. It was only at Pasadena, almost at the foot of the Sierra Madre range, that any number of specimens were obtainable, and most of the colonies sent into New Jersey were obtained from that one locality. The orchards where the species occurred in collectible numbers were all more or less infested by the red scale, which resembles the San José scale quite closely in size, form and structure, but while the beetles were more or

less abundant, they did not by any manner of means control even this red scale, which has but a small fraction of the reproductive power of the pernicious scale. Nevertheless, this *Rhizobius* is the only one which offers any chance of successful introduction into New Jersey. It has shown its ability to spread by extending over so large a portion of California without artificial effort made to distribute it, reaching from the southern boundary as far north, at least, as Marysville, and without doubt beyond and through the whole Sacramento Valley fruit region. It has shown, in this, a power of adapting itself to circumstances, and of moving with considerable rapidity without being artificially transported from place to place. Therefore, while I could hardly feel that the insect would be of any practical use to our fruit growers as against the San José scale, nevertheless it is a species which, if it becomes domesticated in New Jersey, will be useful against armored scales in general. Elsewhere I have given a record of the colonies that were received, and have mentioned the points at which they were liberated.

The larvæ of the Rhizobiids resemble each other in a general way. They are of a rather light-gray color, a little flattened, quite broadly oval, without distinct spinous processes, and are rather sluggish in their movements.

SOYMNIDS.

Closely allied in general size and appearance to the Rhizobiids are the little species of *Soymnus*. They have the same general appearance, much the same coloration, or rather lack of color, and to the untrained eye offer few points of distinction. They are perhaps not quite so convex as are the Rhizobiids, and seem to be more nearly circular in outline, or less oval. Like the *Rhizobiids*, they are also clothed with a very fine pubescence or dense hairy vestiture; but this is applied closer to the body and is not mixed with stiff, bristly hair. The surface is also less shiny, and does not seem to have a bronze reflection; yet it requires a skilled entomologist to discover in all cases the difference between the two groups. Practically it makes little difference to the agriculturist what the minute structural differences between them are. Our Soymnids are largely scale-feeders, yet we do not know, in most instances, to just what extent they also feed upon other things. We know that some species attack the "red spider;" that several of them feed principally upon plant lice, and we do not know positively that more than a very few of them feed exclusively upon scale insects.

In the East, the species of *Scymnus* are rather rare, and it is seldom that any considerable number of specimens of any species can be found. In California, where insect life is on the whole much more active, several species become quite plentiful, and perhaps the most common is

SCYMNUS MARGINICOLLIS Mann.

(The margined Scymnus.)

This, in its general appearance, resembles *Rhizobius lophantæ*, but it is of a dead black, without the least trace of bronze reflection, and is much less convex. The thorax or neck is more or less brown or reddish, rarely entirely so, but usually with a broad border, leaving only a central black disk. Specimens occur, however, in which the reddish color is reduced to a mere line, and in some instances it disappears altogether; so the entire insect becomes black. This is the most abundant form found in California, and chiefly, if not exclusively, among plant lice. Its resemblance in size and general appearance to *Rhizobius lophantæ* has caused it to be also taken for *Rhizobius debilis*. I have already detailed the fact that all the specimens sent into New Jersey as *R. debilis*, are really referable to this species, and of the Californian insects received during the present season, this forms by all odds the greatest proportion. Unfortunately the complete life history of this *Scymnus* is not known, and while it has been asserted that it feeds upon the San José scale, it is also a fact that it is among plant lice only that it can be collected. I do not know just how far this species is distributed in California; but all the specimens received here came from Santa Barbara county, the region perhaps least likely to give us specimens to survive our winters. If they do, we have an insect that may become useful in dealing with such pests as the melon plant louse; but we certainly do not have one that can become very useful in preventing injury by the San José scale. Dr. Horn, in his notes on the Scymni, gives its range as from a little north of San Francisco to the southern boundary of California.

Closely allied to the species of *Scymnus* is the little

SMILIA (PENTILIA) MISELLA Lec.

(The miserable Lady-bird.)

This is a minute species of lady-bird not much more than half the size of a San José scale, shiny black in color and very broadly oval in outline. It occurs throughout the United States from the Atlantic

to the Pacific Coast and north as far as Canada. It is a typical scale-feeder, and of all our species offers the best chance of becoming of assistance to fruit-growers as against the pernicious scale. It is the only species observed by me in New Jersey which has become at all abundant on infested trees, but I have found it this year in every scaly orchard examined, and in the Riverton orchard of Mr. Edward Lippincott there are some trees on which it occurred in great numbers in all stages. It seems to breed almost as long as the scale itself, and has been recorded from Maryland late in November.* Howard and Marlatt declare that "the beetles seem to prefer the full-grown female scales, and were frequently observed standing astride a scale, almost on end, pushing their heads under the margin of the protecting scale to get at the soft yellow insect beneath." The larvæ of the beetles seem to feed more abundantly on the young scales. The tree on which most of the specimens were found in all stages was that upon which most of the introduced insects were liberated in the Lippincott orchard. In this case a piece of muslin had been tied between the branches so as to form a sort of platform, and a little above it another piece was tied to form a roof. The object was to make a sort of shelter for the insects when first liberated, and to make an examination of the specimens of a sending possible without handling. There was no particular attempt at neatness, and the material was full of folds and creases, especially where it was tied to the branches. It was found in September that the creases in this muslin were filled with *Smilia* larvæ ready to pupate; or, in other words, the insects sought shelter of some kind when ready to undergo their transformations. Scarcely a pupa could be found elsewhere upon the tree, but just at this place everything seemed to have congregated. Howard and Marlatt record that "a favorite place of pupation was discovered to be within the calyx of the pears. This cavity is often literally filled with a mixture of young and old scale insects, and frequently contained full-grown *Pentilia* larvæ, their pupæ and also freshly-issued beetles." It is possible that this species has some enemy that attacks it while in the helpless pupal state, and that it requires shelter in order to enable it to multiply most satisfactorily. It may not be a bad scheme to give the insect the necessary shelter by loosely tying around the trunks of infested trees, above the point of branching, a piece of burlap or sacking, or a

* I have since found it abundantly in Monmouth county in December.

fabric of almost any kind. The figure herewith given indicates the appearance of the beetle, its larva and somewhat its relative size, as compared with the San José scale. Useful as this insect undoubtedly is, it has the disadvantage of aiding in the spread of the scale. Those found crawling about in September were almost invariably burdened with from one to four, or even five, scale larvæ, which clung to the surface of the beetle and were carried by it wherever it went. A flight to an uninfested tree in the near vicinity would serve to at once stock it with specimens.

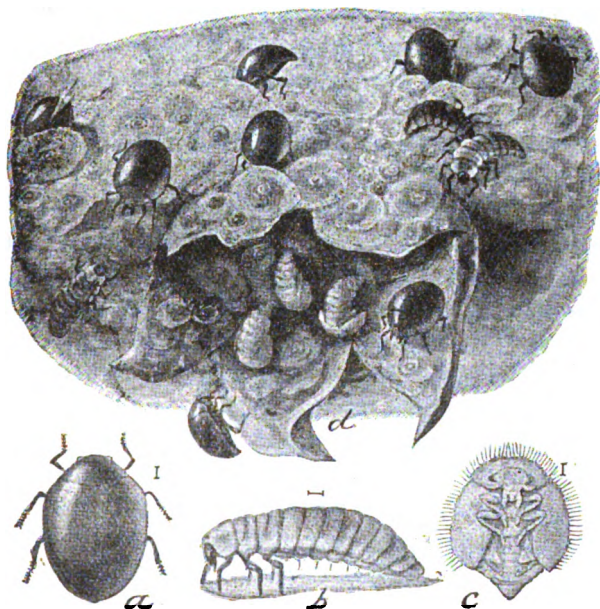


Fig. 10.

Smilia misella, in all its stages: a, beetle; b, larva; c, pupa; d, blossom end of pear, showing scales with larvæ and adults of *Smilia* feeding upon them, and pupæ attached within the calyx; all greatly enlarged. (From Division of Entomology, U. S. Department of Agriculture.)

Another insect that was found in California, feeding rather sparingly on scale-infested trees, was *Cybocephalus californicus* Lec., a beetle belonging to an entirely different family, the *Nitidulidæ*. The insects of this family are, as a whole, feeders upon fungi or more or less decaying vegetable material, yet there seems to be little doubt that this particular species feeds upon the San José scale, and probably others as well. The insect was found in small numbers at San José,

and it is more than likely that where it has been observed it has been taken for a very small *Soymnus*, or for the *Pentilia misella*, which it resembles in appearance, but than which it is even smaller in size. As the insect could hardly be considered a common one, no effort was made to introduce it into New Jersey.

SUMMARY.

We have no good basis for believing that any of the insects introduced into New Jersey from California, or which can be introduced from that State, will become sufficiently abundant in a measurably short time to be of use in keeping the pernicious scale in check. The two species which have done the most effective work in California are already natives of New Jersey and require no introduction. Climatic differences make them less effective with us than they are on the Pacific Coast. We can probably count that both the *Aphelinus* and the *Chilocorus* will in time become increasingly abundant. Our most active species is *Smilia* (*Pentilia*) *misella*, which thus far offers the best chance of an effective enemy. We cannot hope, however, that it will increase sufficiently to become an important aid for a considerable number of years to come, and it does not seem as if our fruit-growers could afford to wait for this or the other species to increase without taking active measures for the destruction of the scale.

DISEASES OF THE SCALE.

The pernicious scale, like all other insects, is more or less subject to disease. There is every reason to believe that disease has been an important agent in destroying the scale in many parts of California. It is reported that in some localities in Florida disease has almost exterminated it. It is reported from Maryland that there seemed a lack of vitality in the larvæ at one period during the summer when examination was made, similar to what I observed in California in May and June. Nothing like a real disease has yet been discovered on the scale of New Jersey, but there is no reason to believe it will be more fortunate here than it has been elsewhere, and we may expect that in the near future some natural check of this kind will moderate its progress. None of the diseases have yet been studied sufficiently

to enable us to say what they really are, nor can we, thus far, propagate them. This line of research is by no means abandoned, however, and studies are being made with the object of discovering what diseases attack the scale and which, if any of them, can be propagated artificially and used for inoculating the specimens on the trees. This is a branch of the case that can only be mentioned here, at present, as being under consideration. It will remain for the future to decide what we can do in this direction.

RECORD OF INSECTS INTRODUCED INTO NEW JERSEY.

Although the observations made in California do not promise well for the success of natural enemies in dealing with the scale in New Jersey, it was nevertheless deemed advisable to do all that was possible to get into the State such species as offered even a remote chance of being beneficial.

It is well established that, in parts of southern California, the pernicious scale began to lessen in number in 1889, and was already well under control in 1890 and 1891. *Rhizobius ventralis*, *R. debilis*, and the species of *Orcus* were not introduced until 1892, hence they could not possibly have had any influence on previous occurrences. *Rhizobius lophantæ* or *townombæ* was already well distributed at that time in California; probably from some accidental importation long before Koebele sent it from Australia in 1890, on his first trip. It was not rare in the cañons of the San Gabriel range, north of Pomona, in 1891, and was found in some numbers at San Diego in 1892, feeding there on the San José scale. The date, 1891, is from specimens in the collection of Professor H. C. Fall, of Pomona, and reliable. It had not at that time been noticed in numbers in badly-infested orchards, but that it feeds among other things upon the San José scale, was established by direct observation in 1892.

Rhizobius ventralis is not claimed as an effective feeder on armored scales, and as we have no soft scales of any consequence in New Jersey, there was no use in attempting to bring it into the State. Of *Rhizobius debilis* great tales were told, and it was positively stated that it feeds largely on the pernicious scale. I could not find any examples myself, but was assured that "later" they would be plentiful.

Oreus chalybeus was confined to one orchard in Los Angeles county and did not seem to adapt itself well to the new surroundings. Of the native insects found feeding on the scales we already have the *Chilocorus bivulnerus* and *Aphelinus fuscipennis*, but do not have the *Euxoehomus pilatii*.

It was at once obvious that I could not, within reasonable limits of time and expense, collect colonies of these insects myself. While they were always abundant in conversation, neither I nor my guides could find them in the orchards, and they were always said to be most plentiful at some other place. It seemed cheaper, then, to engage native collectors to follow the specimens or to induce some of the horticultural commissioners to send colonies into New Jersey when the insects became numerous.

At Santa Barbara I effected an arrangement with Professor T. N. Snow, under which he agreed to send into New Jersey sixty colonies of from fifty to one hundred beetles each, to be equally distributed to the list published on a previous page. The insects were to be chiefly Rhizobiids, and *Rhizobius debilis* and *R. lophantæ* were to form the greatest proportion of each sending; the former to equal at least fifty per cent of all that was sent.

Prior to my departure for California the following letter of instructions was sent to all correspondents:

"DIRECTIONS FOR TREATING THE CALIFORNIAN INSECTS.

"Insects will be sent from California in either the egg, larva, pupa, or adult stages. As far as possible only one stage will be sent in a box, though eggs may hatch on the way. The eggs are small, oval and yellow in color, and will be found grouped in little patches on leaves or twigs, as the case may be. If the insects reach you in this stage, keep them in the house; put the material into a large tumbler, which should be kept covered by some linen or cotton stuff, or a piece of cheesecloth; put into the tumbler a few cuttings of twigs containing San José scales, and examine every day until the eggs are hatched and the larvæ begin feeding on the scales. Then handle as directed for the larvæ.

"The larvæ are small, blackish-gray or mottled grubs, with little branched spines in most cases and rather long legs. If the insects

reach you in that stage, place them on a tree infested by San José scales rather early in the morning of a sunny day.

"In the pupa stage the insects are rather shapeless, somewhat yellowish and black spotted. They will be found attached by the tail, coiled up in a bunch and quite at rest. If they reach you in this stage keep them in the house in the same box in which they were received; leave the cover off the box and place it in a covered glass dish of some kind, where it will be convenient to watch for the appearance of the beetles. When the beetles come out keep them twenty-four hours and place a twig or two containing scales in the dish, that the insects may feed if they choose. At the end of that time liberate the insects on some scale-infested tree in your orchard.

"The beetles are small, more or less hemispherical creatures, smooth or with very fine down only, either black or with yellow or red spots, and they move about rather slowly. They resemble the common lady-birds except in color, and are usually much smaller; one species may be deep blue. If the insects reach you in this stage liberate them upon the trees as soon after receipt as possible.

"All the parcels will be marked as coming from John B. Smith, California, and they should be opened at once on receipt, that you may know just exactly which stage you have. I will try to send a letter with each shipment; but this may not be possible, and in no case should you await a special letter before opening the box. Select a tree upon which to place the insects that has not been sprayed with kerosene emulsion, and if possible one that has received no treatment whatever. If all the trees have been treated, select one that has been treated the longest. If, when you receive the insects, scale larvæ are hatching, place the specimens on a tree upon which they are most abundant. Do not place the insects outside on a cold or wet day. If when you receive them it is raining, or the atmosphere is damp and chilly, keep them in the house until the sun is shining again, and place with them, if in the proper stage, an infested twig, that they may have food. The best time to set them out is on the morning of a bright, warm day. It is not advisable to set them out in the middle of a very hot day, nor in the evening, when they are liable to become chilled by the night air. After the insects have been placed on a tree, visit it occasionally and see whether you can find specimens, and observe, if you can, whether they are feeding upon the scales. Keep a watch also for the appearance of new eggs and larvæ, to

ascertain if the insects are actually breeding in your locality. It is possible that you may receive shipments daily for several days in succession. If you should be called away from home during the period between the middle of May and the tenth of June, please leave instructions with some member of your household concerning the handling of the insects."

Most, if not all, of the correspondents were informed by letter of the fact that sendings would not be made by me, but by Professor Snow and others, in time to avoid any accidents to sendings by the change in plans forced upon me as previously described.

At Claremont, two of the students of Pomona College agreed to send weekly into New Jersey colonies of *Rhizobius* and other desirable species for a suitable consideration.

At Los Angeles, Commissioner Scott very kindly promised to send colonies of any species that became plentiful, and Mr. Kercheval, in whose orchard the *Orcus* was found, promised to let me have a few colonies when the beetles became somewhat more numerous.

At Pasadena, Dr. S. M. Woodbridge agreed to send a colony weekly, as soon as I notified him of my return, for the actual cost and outlay of making sendings.

At San Francisco, Mr. A. Crow, quarantine officer, promised to send me colonies of *lophanta* if any came into the possession of the State Board of Horticulture, but, owing to lack of funds, they were not making free distributions in 1896, and might not get any specimens.

At San José, Mr. Edward M. Ehrhorn, commissioner for Santa Clara county, promised to send me specimens of such Coccinellids as became abundant during the season.

It seemed, thus, that if the desired insects were in any way nearly as abundant as was everywhere claimed, there ought to be imported into New Jersey specimens enough to give the species a fair show of gaining a foothold before cold weather set in.

Professor Snow carried out his contract in that he sent into New Jersey fifty-two colonies of specimens, four others to Washington, D. C., and four to Florida. One set of colonies reached New Jersey before my return, a second came a few days afterward and the whole number of colonies was completed in August; four others were sent in response to a subsequent request, and one was shipped directly

to me. That I might see what species had been received, I wrote to all the recipients asking that any dead specimens of the shipments be sent in for examination, and I received from most of them in return what specimens remained in the boxes. In the first lot a few specimens of *Rhizobius lophantæ* were found and more *R. ventralis*, which were not especially desired; but the bulk of the specimens proved to be *Scymnus marginicollis*, which Professor Snow had evidently mistaken for *Rhizobius debilis*. The colony sent me contained no *Rhizobius* at all except a few *ventralis*, and none of the colonies subsequently received contained either *R. debilis* or *R. lophantæ*: *Scymnus marginicollis* did duty for both. It so happened that I was able to see four of the colonies received by correspondents just as they came in, and two of them I opened myself, in each case finding the *Scymnus* the principal feature of the sending, mixed with a few common beetles belonging to several other families; but in no case was there either a *Rhizobius debilis* or *R. lophantæ*. Two of the four sendings received at Washington were carefully examined by Mr. E. A. Schwarz, one of the best coleopterists in North America, and he also declared that neither of the desired *Rhizobiids* was in the sendings. *Scymnus marginicollis* did duty for all. As Professor Snow insisted that he had sent both *debilis* and *lophantæ* in all the colonies, it is evident that he does not know the true species at all, and whatever he has said and written of them must be accepted with very decided reservation. From the fact that he sent no *debilis* at any time, it is fair to assume that none exist where he collected, and from the fact that *lophantæ* occurred in small numbers in his first sending only, it seems to be a rare or local form near Santa Barbara.

It is certain, however, that a considerable number of *Scymnus marginicollis* reached New Jersey in good condition, and as the *Scymnids* contain many scale-feeding species, this, if it survives, may be of some advantage. It must be pointed out, however, that the insect is usually found most abundantly among and feeding upon plant lice in California; hence it is doubtful whether we can hope for much from it on the pernicious scale.

Early in September I sent letters of inquiry to all who had received *Coccinellids* from Professor Snow, asking their general condition on receipt, whether any of them had been subsequently noticed and whether any larvæ had been observed.

The Messrs. Parry replied, quoting from their notes: "6-20:

To-day received a box with perforated lid from T. N. Snow, Santa Barbara, Cal. The beetles it contained were nearly all alive, between forty and fifty, but would fly away as soon as liberated. 6-22: Received more beetles from T. N. Snow, Santa Barbara, Cal.; mostly alive. 7-6: Received another colony of predaceous insects from T. N. Snow in good condition. 7-13: More lady-bird beetles from T. N. Snow."

They add that they had seen nothing of the beetles, except possibly of *bivulnerus*. "Saw a spider devour one little fellow soon after he was liberated."

Mr. Benjamin Lippincott replies, September 9th: "Rec'd four lots of lady-birds from Mr. Snow. The first lot was nearly all dead; the second a little better; and the third and fourth were in good condition. Should think about 125 were living in the four lots. Have not seen anything of the insects or their larvæ since they were liberated."

Mr. John S. Collins reports the receipt of three lots of insects, containing perhaps eighty living specimens. "I have been looking for the lady-birds, but have so far not seen any since liberating them."

Mr. Howard G. Taylor writes: "I am sorry not to be able to report more definitely on the Californian lady-birds, but made no memorandum of the shipments. The first came about the middle of June, most of them dead; after that saw but few dead ones. They scattered so quickly did not count them. Received the last lot early in August (the 5th); the others came about two weeks apart. Have not been able to see any of the lady-birds or their larvæ feeding on the scale. I think the sender, T. N. Snow, claimed there were over fifty in each lot." I think it fair to assume that there were at least 100 living specimens received by Mr. Taylor.

Mr. Arthur J. Collins writes: "Rec'd three lots of lady-birds from California this summer. I can see nothing of them at this time." Mr. Collins had in previous letters acknowledged the receipt of the specimens in good condition, hence we may estimate 100 as a fair number probably received.

Mr. George W. Stokes wrote: "Replying to yours of September 3d, will report as follows: I received four sendings from California, approximating 150 living insects. After putting these out they soon disappeared. Presume they flew away."

Mr. Charles K. Van Sciver: "Received in the months of June

and July four shipments of lady-birds from T. N. Snow, of California, and placed them on Keiffer pear trees infested with the San José scale. They came in rather weak condition, and after placing them on the trees at two different times, it was followed by rain accompanied with considerable wind. I fail to find any trace of them now."

Mr. Edward Lippincott received the full number of four sendings, and in his orchard I kept track of what arrived myself, and saw to the liberation of some of the colonies. At least 150 living specimens were received here from Mr. Snow. Nothing could be seen of them September 8th.

Mr. Charles Parry also received four sendings and liberated all the specimens in the orchards of Parry Brothers. From the information given me there must have been at least 100 living specimens, and as many in the sendings to Parry Brothers, making at least 200 specimens liberated there.

Mr. E. T. Gill received four sendings in good condition, one of which I opened myself, and at least 125 living specimens were received and liberated in his orchard. Nothing was seen of them afterward.

Mr. Horace Roberts received "five shipments of lady-birds from T. N. Snow, all in very good order except one that was only about half living. The other had very few dead bugs, or bugs too lazy to walk out. Since turning them loose I have not been able to find them." This would give Mr. Roberts nearly 200 living specimens.

Mr. Geo. L. Gillingham received four colonies, three of them in good condition, one of them with but a very few living specimens. All were liberated as directed and nothing has been seen of them since.

Mr. J. J. Albertson received a single colony only, with about twenty-five living specimens.

Altogether, then, there were received in New Jersey, from Mr. T. N. Snow, about 1,500 living specimens, of which perhaps one hundred were *Chilocorus bivulnerus*, perhaps fifty were *Rhizobius lophantæ* and the remainder were *Soyumnus marginicollis*. While nothing has been seen of the specimens since they were liberated, this does not prove that they have died. They may be found next summer, if they can survive our winter. It must be remembered, however, that in their home, Santa Barbara county, frost is practically unknown,

rains are not very severe, and heavy winds are not common. I would not expect the insects to survive a zero temperature. It has been already stated that *Seymnus marginicollis* is not a specific scale-feeder. It is most abundant among plant lice, and is not likely to do much on our scale-infested trees. It was sent in as *Rhizobius debilis*; but if it survives it may be of help against some of our plant lice.

The following letter, from one of the students at Pomona College, to whom reference has been made, will explain itself:

"REDLANDS, Cal., July 6th, 1896.

"Mr. J. B. Smith, New Brunswick, N. J.:

"DEAR SIR—You are probably wondering why you have not received any beetles, as yet, from us. We have been greatly discouraged in our attempts to find localities in which they may be found. Professor Fall writes that he knows of no place in which we could find them at all numerous. Mr. John Scott, of Los Angeles, writes the same, and adds that the beetles named do not feed at all voraciously upon the pernicious scale. Professor Cook also, and commissioners of San Bernardino and Riverside counties, write me that the beetles occur in very small numbers. These facts have led me to question the wisdom of our spending the time necessary or the money for our expenses. I have hunted one day near Santa Ana, but collected less than fifty. I am sorry not to be able to fulfill the bargain as agreed, but it seems impossible to do so here. I sincerely hope you will have success in obtaining efficient enemies from other quarters.

"Yours very sincerely,

(Signed)

"WM. T. STERLING"

Concerning *Orcus chalybeus* near Los Angeles, Mr. George Compere wrote me July 3d: "I was down to the Keroheval orchard on June 29th, but could not find *Orcus chalybeus*. Could not find even one, but will go down in ten or fifteen days and see if they have started."

No specimens were sent me during the season; therefore it is probable that they did not start.

July 14th, Commissioner Scott, of Los Angeles, wrote: "Your experience in the northern part of this State in regard to the work of parasites on pernicious scale is what I expected. I send by this mail a colony of *E. pilatii*. They are not very numerous here, and it is difficult to get colonies. *Orcus chalybeus* have entirely disappeared for the present, but will no doubt show up again, when I

will forward colonies to you. I think that the *Chilocorus bivulnerus* is much more efficient as a scale destroyer than *E. pilatii*, or in fact any of our lady-birds (always excepting *Vedalia cardinalis* for white scale). I shall send you some colonies of parasites whenever I can, until you ask me to stop, or until the cool weather sets in."

The colony of *Exochomus pilatii* came duly to hand in good condition and was liberated in the Riverton orchard of Mr. Edward Lippincott. They had disappeared a week afterward and have not been seen since. No further colonies were received from Mr. Scott, hence I take it that predatory insects did not become abundant anywhere in his bailiwick.

Dr. S. M. Woodbridge, of Pasadena, sent the most valuable series of colonies into New Jersey, consisting of *Rhizobius lophantæ* and *Chilocorus bivulnerus*. The latter species was sent in the hope that the specimens coming from California might breed more rapidly than do our natives, and in one case at least an effort seems to have been made in that direction. What the outcome will be, remains to be seen. Dr. Woodbridge sent four colonies to Parry Brothers, and to me he sent colonies June 21st, July 5th, 19th, 30th; August 2d, 6th, 22d and 28th—in all, eight colonies, varying in condition. One of these was sent to J. J. Albertson, Magnolia, N. J.; four were liberated at Riverton, in the Edward Lippincott orchard; one was placed on a tree infested by *Pseudococcus aceris*, in New Brunswick, and two arrived without living specimens of *lophantæ*, the box having air holes large enough to permit their escape. In all, perhaps 250 to 300 specimens of *Rhizobius lophantæ* were received in viable condition.

Mr. Craw's numerous duties allow him little time to collect, and his only contribution was the statement in a letter of June 15th: "I collected several colonies of *Rhizobius ventralis* in Alameda county last week, and sent two to Professor Howard. I did not see a single *toxocombæ* that day."

From Mr. Edward M. Ehrhorn, I received, during the summer one colony of *Exochomus pilatii* and several of *Chilocorus bivulnerus*, all of which were liberated in the Edward Lippincott orchard, at Riverton. The *R. lophantæ* did not become abundant enough, apparently, to make it possible to collect more than one small colony.

This record shows that the predaceous insects supposed to be of so

much benefit in keeping down scale insects in California are by no means so universally present as current representations would indicate. Professor Snow, who has been a champion of such insects in the public prints, failed to send even a single specimen of the species for which he has had so much praise, and only from one locality did I get *Rhizobius lophantæ* in quantities worth sending.

It is impossible to say, as yet, what the result of these importations will be. Our cold, wet winters are so utterly unlike the mild winters of California that, theoretically, no insect used to the latter climate can survive the former.

Nevertheless, this line of work will not be abandoned; only instead of attempting to introduce species from a warmer country, some of the species of northern Europe will be secured if possible; or Japanese species. The experience of the past has been that Japanese plants do extremely well in the eastern United States, and it may easily be that the same rule will hold true as to insects. It is in this direction that future efforts must be made rather than toward California or any portion of the southern hemisphere.

Nevertheless, we have one point to consider which is of the greatest importance. In our climate most beetles breed slowly, and from a nucleus of say 1,000 specimens, several years would have to elapse before a species would be in a position to be even a factor in keeping a species like the pernicious scale in check. Can we afford to wait that long for the chance that our colonization scheme will be successful? Mr. Arthur J. Collins, of Moorestown, writes on this subject of his own motion and not in response to any question of mine: "I think if trees are *well sprayed* with soap and potash, we can get better results than by importing lady-birds."

LIFE HISTORY OF THE SCALE.

The pernicious scale is found during the winter in all stages of growth, from the larva recently set to the adult capable of producing young. It is probable that most of the very young, and of the reproducing adults, die during the winter, leaving the half or three-quarter-grown examples as the nucleus for the next season's crop. Males begin to appear in New Jersey before the middle of May, and these impregnate the females, which reach maturity a little later. The

first young or larvæ make their appearance on the infested plants during the last days of May or early in June—depending somewhat upon the temperature—and are then almost microscopic in size, orange yellow in color, with six short legs, a pair of short, jointed feelers or antennæ, and long, bristle-like sucking mouth parts. They are just visible as yellow atoms when they move about actively on the plants, and in this stage they do whatever traveling is in their power. They may remain active a few hours only, or for a day or

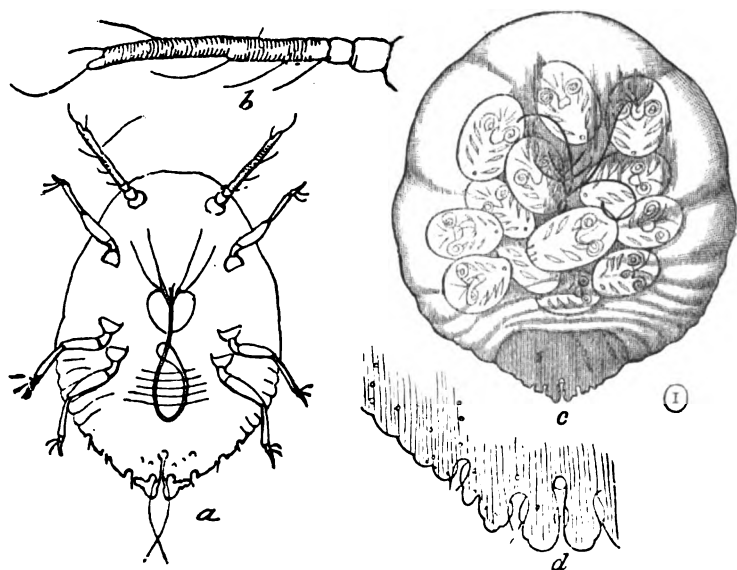


Fig. 11.

a, larva of the pernicious scale, very much enlarged; b, its antenna, yet more magnified; c, the female, showing young through the body wall; d, outline of anal plate of female. (From Division of Entomology, United States Department of Agriculture.)

two, and are unable to crawl for any great distance, as from tree to tree, over the ground. Except in nursery rows, settlement is usually made on the tree on which the insect is born, unless it be transported on the feet of birds, or on other insects, to other trees or orchards.

This dependence upon outside aid for spreading, explains why sometimes only one or two trees in an orchard are badly infested, while all around are entirely clear. After the larvæ have run about for a time without food, minute, white, waxy filaments begin to appear through specialized pores in the body; the insects become more rounded in form, and when they find a suitable point on twig,

leaf or fruit, they gradually work their slender beak deep into the plant tissue and are then permanently fixed. The waxy filaments become more numerous and longer, until the insect is entirely covered; then they fuse into an even coating, and the first scale is completed. It is then almost white in color and somewhat lenticular in shape, soon becoming more flattened, and showing a central, nipple-like prominence, which remains present afterward. The insect beneath this scale continues feeding, and small as it is, produces a distinctive effect upon its food plant, usually visible as a reddish discoloration. This is particularly marked on the fruits of apple and pear, and an infested tree is often most easily recognized by the prominent red spots on the fruit. In about ten days after the scale has formed, the insect beneath it molts or casts its first larval skin, which then forms part of the enlarged scale, now of an ashy-gray color or even darker; the central nipple paler or yellow. In this stage the creatures are without legs or other appendages, but the future males are already recognizable by a somewhat more elongate-oval shape, and by a pair of purple eye spots. The females have no perceptible organs except the beak, and this they employ continuously. In about eighteen days from birth the male begins to pupate, and in twenty days the true pupa is completed, the adult backing out from beneath its scale four or six days later, or from twenty-four to twenty-six days after birth.

The female molts, a second time, about twenty days from birth, and becomes adult about ten days later. The cast skin of this molt is also added to the female scale, which thus becomes considerably larger than that of the male. The female does not change perceptibly in form at this molt, and remains legless and grub-like as before. The forming embryos soon begin to show through the skin, and larvæ begin to appear on about the thirty-third day. The young are born alive, and after a brief period of rest crawl from beneath the mother scale to commence for themselves a life cycle like that just described. Reproduction by the female continues for about six weeks, at an average rate of more than ten each day, resulting usually in from 480 to 500 young from a single specimen. As many as 587 have been, however, actually counted from one female. Before the over-wintered females have ceased to reproduce, their first descendants have begun to multiply; hence, the broods become mixed after the beginning of July, and young larvæ may be found crawling on infested trees almost continuously until frost sets in and the trees become dormant. This

does not take place in southern New Jersey much before December, hence reproduction continues until nearly that time, and I have actually seen recently-set scales in Burlington county about the 10th of December. This gives time for nearly five full broods in the course of the season, and during this period the descendants of a single female may reach the enormous figure of 1,608,040,200!

In this history free use has been made of the exact figures given by Howard and Marlatt in the Bulletin No. 3, previously mentioned,

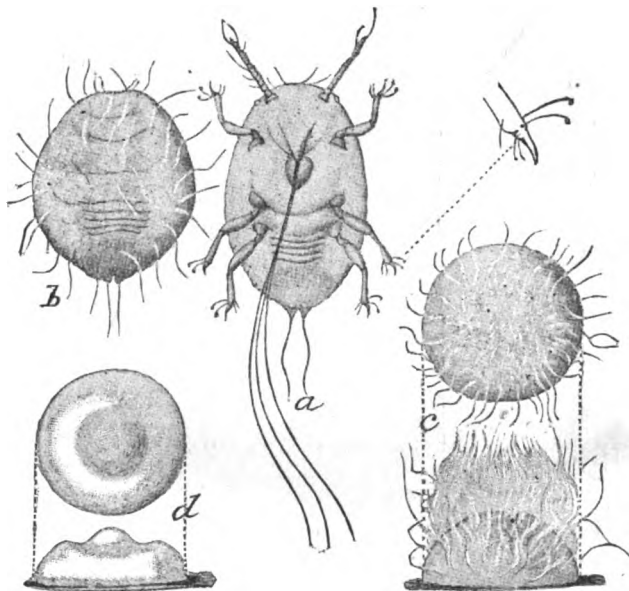


Fig. 12.

Young larva and developing scale: *a*, ventral view of larva, showing sucking beak with the bristles separated; *b*, dorsal view of same, somewhat contracted, with first waxy filaments appearing; *c*, dorsal and lateral views of same, still more contracted, illustrating further development of wax secretion; *d*, later stage of same, showing matting of the waxy filaments and the first form of the young scale—all greatly enlarged. (From Division of Entomology, United States Department of Agriculture.)

but I have verified them in all important points. My own experience differs only in that it seems to indicate a slightly shorter time for the full development of the insect.

When a tree is badly infested it becomes so incrustated with scales that the bark itself is absolutely invisible and seems covered by a gray, scurfy deposit. Quite frequently the young find every bit of available space occupied and are compelled to fix through the old scales, making in some places a double layer. When scraped with a

knife or the finger-nail, a yellowish, oily liquid results from crushing the insects beneath the scurfy covering. This affords a good rough-and-ready way to determine the effectiveness of a wash on a badly-infested tree. If, on scraping, the oily liquid appears, the insects are alive and the application has been ineffective, in very large part at least. If, on the contrary, the scurf comes off dry, and only flattened, pale-yellow or whitish insects are seen, the application has been in



Fig. 13.

Appearance of the scale on bark : a, infested twig, natural size; b, bark as it appears under a hand lens, showing scales in various stages of development, and young larvae. (From Division of Entomology, United States Department of Agriculture)

very large part effective, and for further examination a lens must be employed.

The female scales are almost circular in outline and in extreme cases have a diameter of 2 mm., or .08 of an inch; but when they are at all abundant, they rarely exceed one-half of that. The male scales are a little oval and rarely exceed 1 mm., or a little less than one-twentieth

